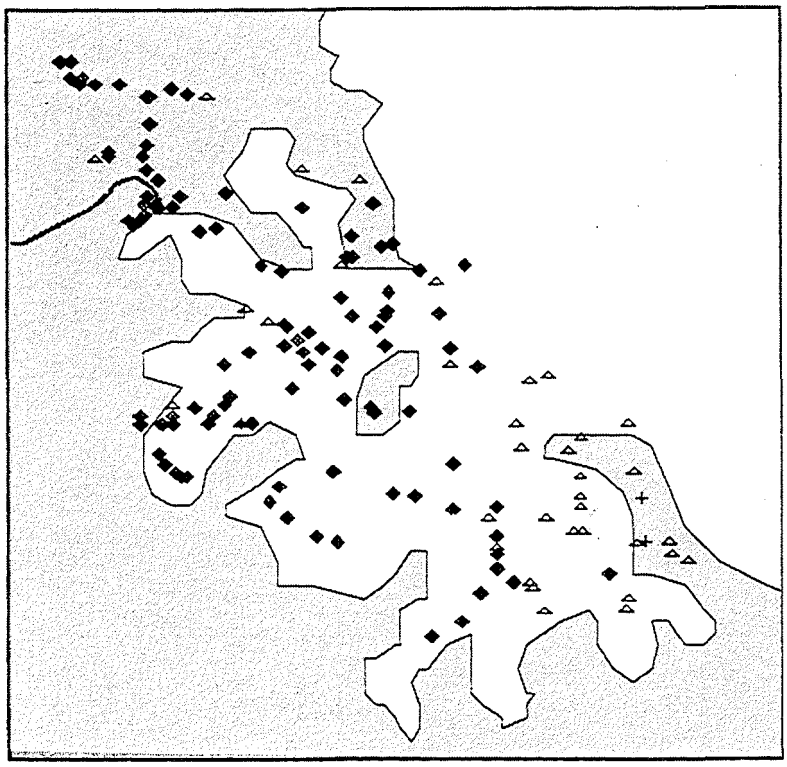
NOAA Technical Memorandum NOS ORCA 76

National Status and Trends Program
for Marine Environmental Quality

Inventory of Chemical Concentrations in Coastal and Estuarine Sediments



Silver Spring, Maryland
January, 1994

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Coastal Monitoring and Bioeffects Assessment Division
Office of Ocean Resources Conservation and Assessment
National Ocean Service

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Notice

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Inventory of Chemical Concentrations in Coastal and Estuarine Sediments

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Silver Spring, Maryland
January, 1994

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Department of Commerce

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Atmospheric Administration

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ABSTRACT

This report describes the results of an inventory of sediment contamination undertaken by the National Status and Trends (NS&T) Program. The resulting COastal SEdiment Database (COSED) of chemical concentrations, consisting of nearly 13,500 coastal sediment samples along the continental US coast, was compiled from various electronic information systems (NOAA/NS&T, STORET, ODES, the Environmental Protection Agency (EPA) Region 4, EMAP/EC, SFTB). Data on the concentrations of over 80 analytes, including metals, pesticides, polyaromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCB), and physical sample parameters were assessed relative to the NS&T "High" concentrations, which correspond to the geometric mean plus one standard deviation of all NS&T site means The spatial distribution among all COSED sites reveals more areas with "High" concentrations along the coasts of the Northeast and Gulf of Mexico than in the Southeast or West Coasts The greatest numbers of sites with concentrations greater than five times the "High" (5xHigh) were near densely populated areas in poorly flushed water bodies (harbors, intracoastal waterways, etc.). The most common chemicals at these "5xHigh" levels were metals, in decreasing frequency: Hg, Cd, Sn and Ag. Total PAH was the organic compound group most commonly found in the "5xHigh" range.

It is recommended that the random dataset being generated by the EMAP/EC be used to establish the areal extent of chemical concentrations. While EMAP/EC does not provide data on small spatial scales, its random sampling scheme is ideal for large scale and national assessments. Based on EMAP data, more than 90% of the corresponding coastal and estuarine areas have concentrations below "High", while "5xHigh" concentrations are exceeded only in a very small fraction of the area.

INTRODUCTION

Coastal and estuarine areas are of interest due to their ecologic, economic, and recreational importance. Rivers carry suspended particles into these areas where, under the influence of salinity and lower current speeds, they usually settle to the seafloor. These particles can carry chemical contaminants discharged to the rivers, and, along with direct inputs of contaminants, increased marine traffic, growing human populations, and atmospheric deposition, contribute to coastal sediment contamination

The magnitude and extent of sediment contamination has been a subject of major emphasis in recent years. Concerns raised by scientists and the public over contaminated sediment management and remediation have increased the costs of industrial and municipal waste treatment and, especially, the cost of dredging navigable waters. However, while some efforts have been undertaken to categorize sediments in the U.S. (Bolton et al, 1984; Lyman et al, 1987; NOAA, 1991), the extent of sediment contamination remains largely undefined. A detailed evaluation of coastal sediment contamination has therefore been mandated by the Water Resources Development Act of 1992 (WRDA), which requires NOAA and USGS to assist the EPA in conducting a comprehensive national survey of data regarding aquatic sediment quality in the United States.

There is a large body of data, generated in the past, for use in defining the extent of coastal and estuarine sediment contamination in the US. The goal of this work has been collection, evaluation, and organization of these data to make that assessment. While precise distributions of contamination over local spatial scales will usually not be derivable from data collected at fairly low spatial resolution, the available data do allow national and regional assessments.

This report was compiled from existing data for the coastal and estuarine United States, retrieved primarily from computerized information systems. Six sources were used, two from NOAA and four from EPA. The NOAA sources were the National Status and Trends Program (NS&T) and data from San Francisco and Tampa Bays used for two NOAA reports, Long et al. (1988) and Long et al. (1991), respectively. Data used for those two reports were provide by E. Long (NOAA, Seattle) and have been digitized and combined into a dataset called "SFTB". The EPA sources were the Storage and Retrieval of U.S. waterways parametric data (STORET), the Ocean Data Evaluation System (ODES), EPA Region 4 compiled data (REGION4), and the estuarine component of the Environmental Monitoring and Assessment Program (EMAP/EC).

In 1984, NOAA initiated the National Status and Trends program (NS&T) to monitor contaminants in fish, mollusks, and sediment at over 300 coastal stations. Sites were chosen to represent rather large areas and are therefore not in industrial waterways or near discharge pipe outputs. Recently, the NS&T program has been extended to intensively sample, on small spatial scales, some enclosed water bodies near populated areas that were expected to be heavily contaminated (e.g. Boston

Harbor, Hudson Estuary, San Francisco Bay, and Tampa Bay). While chemical data are collected in these intensive surveys, they were primarily designed to search for biological effects of contamination. Sediment chemical data exist for 17 elements and 60 organic parameters, making this database one of the most complete of its kind. Quality assurance (QA) efforts are essential to the program, and are designed to produce nationally uniform analytical results of known and accepted quality.

SFTB data were extracted from reports on sediment chemistry in San Francisco Bay (Long et al. 1988) and in Tampa Bay (Long et al., 1991). These data were taken from reports in the technical literature that contained both chemical measurements and results of biological effect measurements. Only the chemical information from the SFTB database was included in COSED.

STORET, according to an EPA definition, is ". . a computerized management information system residing on EPA's computer at Research Triangle Park, North Carolina. It is made up of several software modules which allow the user to store and retrieve water quality information.. " Although STORET contains over 190 million parametric observations, only a small portion of them are sediment data. The data belongs to the agency providing it and are only managed by EPA, thus, quality assurance rests with the data submitter. Numerous chemical and biological parameters are included in STORET, but most sediment datasets contain only a minimum number of chemical parameters. It is important to note that the majority of data in STORET were collected as a regulatory requirement of EPA. As a result, there is a strong tendency for STORET data to be from samples collected near individual point sources of contaminants. We data was retrieved only when described in STORET by the keywords: "Ocean", "Nearshore", "Offshore", "Estuarine" and "Saltwater Wetlands".

ODES provides a centralized system for data management and analysis. It is designed for supporting decision-makers associated with marine and estuarine monitoring programs. ODES contains data mainly from the following EPA programs: 301(h) and 403(c), National Estuarine Program, EPA Regional Ocean Dumping Program, and Great Lakes National Program It also resides at the EPA's computer at Research Triangle, NC. Technical staff run QA and error checking programs, and a brief description of the sampling and analytical methods is provided for many datasets. Over 100 datasets contain sediment chemical information. Like STORET data, the ODES data is dominated by samples taken near points of wastewater discharge.

The Region 4 Coastal Sediment Quality Inventory, provided by C. Fox (USEPA, Washington, DC), was compiled with data from State and Federal agencies (EPA, 1992). It is a dBase III+ file containing chemical data paired, where possible, with biological information. Data sources were primarily: the Florida Department of Environmental Regulation, hard copy reports from EPA, Army Corps of Engineers, and general literature Acceptance of data was based on accurate geographical information of the sampling site, and an effort was made to correct erroneous latitude and longitude values. Only the chemical data from the Region4 database was included in COSED.

EMAP/EC sampling and analytical techniques are largely similar to NS&T, but site selection has been based on a rigorous statistical scheme that emphasizes geographically random site selection (Holland, 1990). Sampling occurs in estuaries and in tidal reaches of rivers over large regions of the United States. To date, sampling has been done in the Virginian Province (mouth of Chesapeake Bay, VA to Provincetown, MA) and the Louisianian Province (all of the Coastal Gulf of Mexico except southern Florida). Sediment chemistry data obtained from 1990 to 1991 sampling in the Virginian Province and from 1991 and 1992 sampling from the Louisianian Province, has been included in COSED.

Within the EMAP/EC and NS&T datasets, it is possible to distinguish between sites selected specifically to test for biological effects at elevated levels of contamination and sites selected randomly or selected to be representative. Site selection in the EMAP/EC Program is random for all sites except those considered index sites or test and evaluation sites These later sites, chosen for a number of different reasons include some where elevated levels of contamination were deliberately being sought, are not random and indicated as such in the EMAP/EC database Sites of the Mussel Watch Project within the NS&T Program are not random because they were chosen for the sake of annually collecting indigenous mussels or oysters. They are, however, considered to be representative of their general surroundings Sites of the Benthic Surveillance Project, include many chosen specifically to examine biological effects at extreme levels of contamination In comparing among datasets, we have differentiated between the EMAP/EC random and non-random sites and between the Mussel Watch and Benthic Surveillance sites It is possible, with closer scrutiny, to subdivide the Benthic Surveillance dataset to separate representative sites from those deliberately chosen for their contamination.

That has not been done because, if it were, the same subdividing would have to be applied to the ODES, STORET, EPA Region4, and SFTB datasets. In those cases, though, sufficient information is not available.

DATA REDUCTION

The chemicals of interest (Table 1) were those routinely analyzed by the NS&T Program, as well as kepone and toxaphene. Data for 1975 to 1992 were retrieved from STORET and ODES using tools supplied in those software packages. Those files were downloaded to a personal computer for further evaluation. All other data were available in IBM-PC or Macintosh format. Every dataset was examined individually and converted to a common format using an X-Base (FoxBase+/Mac or FoxPro/PC), then all data were combined into COSED.

Some general guidelines were followed for conversion of data values to a common format:

- Values entered in original databases as less than a detection limit were converted to zeros.
- Values in STORET labeled as "estimated" rather than measured were converted to zeros.
- All concentrations were converted to ppm-dry (µg/g) for elements and ppb-dry (ng/g) for organic compounds.
- Data were converted to a horizontal format, so that there is a single record for each sample, and examination of the data does not require the use of a relational database.
- Multiple samples from the same site were treated as individual records

Table 1

Elements and Compounds included in COSED

Elements

Al, Ag, As, Cd, Cr, Cu, Fe, Hg, Mg, Ni, Pb, Sb, Se, Si, Sn, Zn.

Organic Compounds

PAH

***2-ring compounds*: acenaphthene, biphenyl, naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, and 2-6-dimethylnaphthalene;**
***3-ring compounds*: acenaphthene, acenaphthylene, anthracene, flourene, phenanthrene, and 1-methylphenanthrene;**
***4-ring compounds*: benz[a]anthracene, chrysene, flouranthene, and pyrene;**
***5-ring compounds*: dibenz[a,h]anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo[a]pyrene, benzo[e]pyrene, and perylene;**
***6-ring compounds*: benzo(ghi)perylene, indeno.**

PCB **A total of 18 individual PCB congeners.**

DDT **DDT and its metabolites DDE and DDD.**

Chlorinated Pesticides : **Aldrin, dieldrin, endrin, cis-chlordane, trans-chlordane, hexachlorobenzene, heptachlor and heptachlor epoxide, kepone, lindane, mirex, and toxaphene.**

- Values appearing as zero in COSED were treated as missing (i e. ignored) when average concentrations were calculated. However, if all attempts to measure a chemical at a given site yielded less than detectable concentrations, a concentration of zero was used for comparisons with other sites.

Although there are methods for dealing with values below the detection limit (DL), their complexity and relative error increases when there are multiple DLs for each variable (Helsel, 1990). This is the case in COSED, because data were gathered from various databases which, themselves, carry data from many sources Occasionally, DLs were reported that were even higher than the NS&T "High" values. While concentrations reported as below DLs are carried in COSED as zeros, in this analysis they have been treated as missing data

Data were converted to a horizontal format with each sample occupying one 120-field record containing all the physical and chemical information for this sample. The alternative or "vertical" method of data storage, where each chemical is carried as a separate record, requires that data for each sample be split among as many records as there were measured chemicals. The "horizontal" approach is preferred by most analysts, because it does not require use of relational databases and allows use of spreadsheets and statistical programs for complex data manipulation and queries. Since "horizontal" files require an equal number of fields in each record, there are records with many empty fields. This method of storing data might appear to increase the size of a file over that of a "vertical" database, but, because all descriptive information about each sample appears only once, "horizontal" files are usually smaller.

Following the initial manipulation, data analysis was performed with individual element concentrations and on aggregated groups of organic compounds, as was done with the NOAA NS&T data, i.e .

•Total DDT (TDDT) = sum of concentrations of DDT (1,1'-[2,2,2-trichloroethylidene]bis[4-chlorobenzene]) and its metabolites DDE (1,1'-[dichloroethylidene]bis[4-chlorobenzene]) and DDD (1,1'-[2,2,-dichloroethylidene]bis[4-chlorobenzene]) and

•Total chlordane (TCdane) = sum of concentrations of two major constituents of chlordane mixtures, cis-chlordane and trans-nonachlor and two minor components, heptachlor and heptachlorepoxide, and

•Total polychlorinated biphenyls (TPCB) = TPCB if listed as such in the original data source. If homolog data were provided, TPCB = sum of the concentrations of PCB homologs at each level of chlorination. If congener data were provided, TPCB=2x∑congeners, an approximation based on regressions developed between homolog and congener data (NOAA,1990), and

•Total polycyclic aromatic hydrocarbons (TPAH) = sum of concentrations of 18 PAH compounds. While the low-molecular weight PAHs (LPAH) is the sum of concentrations of the 2- and 3-ring compounds, and high-molecular weight PAHs (HPAH) is the sum of 4- or more ring compounds.

Concentrations of aggregated groups might not be exactly comparable among all datasets because not all records have data for the same number of individual compounds This, however, is a conservative approach, because organic chemical data from sources other than NS&T and EMAP/EC invariably contain data on fewer individual chemicals.

The total number of samples in the database was 13,433, containing 315,770 individual parameter measurements, of which 175,117 were above detection limits. Sample dates were between 1975 and 1992. Only 19% of the samples were from the NS&T and EMAP datasets, but they contributed over 86% of the individual parameters, indicating that most of the other programs analyzed samples for a smaller number of chemicals. While the number of samples in the SFTB dataset is small, it does contain information for a large number of parameters. The number of occurrences per analyte, presented in Figure 1 and listed in Appendix I, indicated that metals were the most frequently sought and detected analytes. Analyses for chlorinated pesticides, other than DDT and its derivatives, were also frequent but concentrations were often below detection. The frequency of analysis of PAH compounds varied with the compound, increasing for the heavier members of the group. PCBs and DDT derivatives were routinely found only in the NS&T, EMAP/EC, and SFTB datasets.

The STORET, ODES, and EPA REGION4 datasets combined provided 79% of the samples in COSED, but in most samples only a few chemicals were measured Furthermore, data records from those sources generally lacked important information, such as concentrations of aluminum, iron, total organic carbon (TOC), and grainsize. These parameters are valuable for comparison between different sites, because they help to account for differences in concentration that are due to natural, rather than man-made, causes. We will return to this point, but the initial analysis of COSED will be done with raw, unadjusted, concentration data. High DLs are another concern because results of surveys with high DLs instead of the real concentrations are effectively biased toward the higher end of the concentration range. However, that should not affect the results of this report since we are emphasizing areas with elevated levels of contamination. Records with missing station names and coordinates were found frequently in ODES. In about 200 cases, conventional coordinates could be calculated from the state plane coordinates provided by Tetra

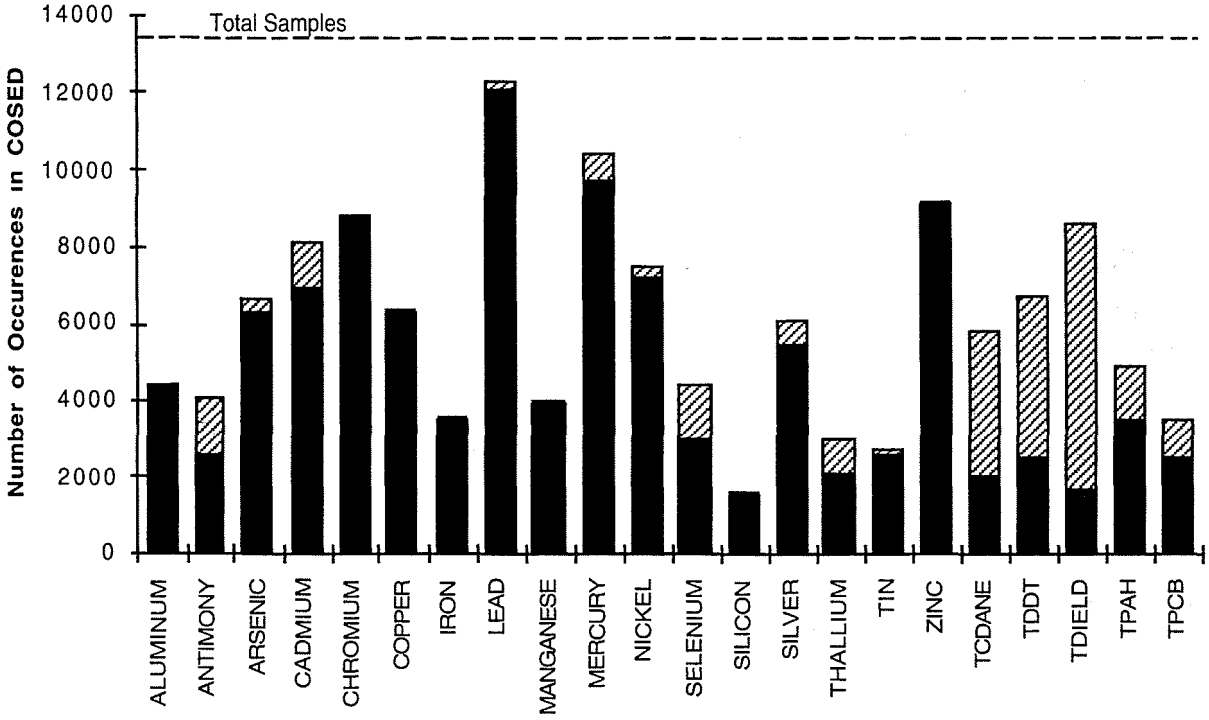


Figure 1. Number of times that each analyte was above (solid column) and below (hatched column) detection in COSED. The dotted line represents the total number of samples. Lead was determined in most of the samples, metals in general were most often found, while organics were often below detection.

Tech Inc , but records were excluded from COSED if conventional coordinates were not given or calculable.

ANALYSIS

Once COSED was compiled, it was attempted to use it to estimate contaminants of concern, frequency of elevated levels of these contaminants, and the extent of chemical contamination in the coastal United States. Two sets of criteria were considered to categorize the raw sediment concentrations:

- The "High" concentration from the NS&T Mussel Watch sediment data (as calculated here) and,

- Effects Range-Low (ERL) and Effects Range-Median (ERM) values which are the low 10th and 50th percentile of the biological effects data, respectively, for each substance (Long et al, in press)

For each set of criteria, the critical concentrations for each chemical are shown in Table **2**. The NS&T "High" values were calculated following a modification of the NOAA (1991) procedure. Only data from Mussel Watch sites were used and the average analyte value per site was calculated. Mean concentrations were converted to the logarithms and then, using all sites, the ~~geometric~~ mean and standard deviation were calculated. The "High" values were defined as the mean plus one standard deviation and were converted to the original units (non-logarithmic). Since mean concentrations were approximately log-normally distributed, the "High" value corresponds to about the 85th percentile. No grainsize normalization was used in calculating "High" values, in contrast to NOAA (1991), because grainsize information was missing from most records in COSED. Thus, the unadjusted "High" values calculated here are about 50% lower than the ones reported in NOAA (1991) The NS&T Mussel Watch dataset was chosen for setting criteria for comparison because it does not contain sites deliberately chosen for their elevated concentrations and because its sites are distributed throughout the coastal United States. The EMAP dataset of randomly selected sites could serve just as well but, currently, it covers only the Virginian and Louisianian Provinces. To emphasize extreme concentrations that exist in COSED, "5xHigh" concentrations were defined as those exceeding five times "High" values.

The ERL and ERM values, also based on raw data, were derived from the Biological Effects Database for Sediments (BEDS) compiled by Long et al (in press) with data on sediment toxicity using estuarine and marine sediments. Data are entered into BEDS only if there are both chemical measurements and results of biological effects measurements. The biological effects may be bioassay results or some attribute of indigenous communities found with the sediment sample. For each chemical, cases for which ~~there was a~~ were biological effects were ranked by concentration, and the ERL and ERM are the 10th and 50th percentile concentrations in that ranking. Concentrations below the ERL value were rarely associated with biological effects. Concentrations in the range between ERL and ERM values occasionally co-occur with

Table 2
Criteria Applied to COSED

Analyte	High	5xHigh	Grain Adjusted High[1]	ER-L[2]	ER-M[2]
Antimony	2.1	10.5			
Arsenic	13	65	24	8.2	70
Cadmium	0.54	2.7	1.2	1.2	9.6
Chromium	125	625	230	81	370
Copper	42	210	84	34	270
Lead	45	225	89	46.7	218
Mercury	0.22	1.1	0.49	0.15	0.71
Nickel	42	210	69	20.9	51.6
Selenium	0.92	4.6			
Silver	0.52	2.6	1.2	1	3.7
Tin	4	20	8.5		
Zinc	135	675	270	150	410
High MW PAH	1730	8650	2900	1700	9600
Low MW PAH	450	2250	980	552	3160
Total Chlordane	4.5	22.5			
Total DDT	22	110	37	1.58	46.1
Total Dieldin	2.9	14.5			
Total PAH	2180	10900		4022	44792
Total PCBs	80	400	200	22.7	180

Units are in µg/g (ppm) for inorganics, and ng/g (ppb) for organics.

[1] NOAA, 1991.

[2] Long et al, in press.

effects. Biological effects were often found to co-occur with concentrations above the ERM value. Usually the "High" concentrations based simply on the NS&T chemical data were within a factor of two of the ERL. The ERM values, on the other hand, were generally within a factor of two of "5xHigh" concentrations.

Each site within COSED has been put into one of three categories:

1) **Low**: Levels of all analytes below the NS&T "High" value as defined in Table **2**.

2) **High**: At least one analyte exceeds the corresponding "High" value.

3) **5xHigh**: At least one analyte concentration is greater than the "5xHigh".

RESULTS

CATEGORIZATION, AND DISTRIBUTION OF SITES

COSED is a sample-based database, thus each one of the multiple samples from the same site appears as one of the 13,443 individual entries. Sites, on the other hand, are distinguished solely on the basis of their coordinates. There are 3,878 separate sites, each with a distinct specification of latitude and longitude No attempt was made to combine sites that were nearby one another The average values for each site have been calculated using all data above the detection limit, and were used for all subsequent site characterizations. Table **3** lists the total numbers of samples and sites in COSED and the numbers in each category. Half the sites are represented by single samples, 35% were sampled two to five times, and three sites were sampled over 100 times. Most of the sites with more than five samples were retrieved from STORET or ODES and were located in Texas or Orange County, CA.

Table 3

COSED data statistics. Number of samples and sites in each category.

	Samples	Sites
Low	6715	1127
High	5525	2154
5xHigh	1203	597
Total	13443	3878

With more than three thousand sites, COSED is, to our knowledge, the largest database for coastal sediment chemistry (The EPA is currently compiling a larger set, which will include COSED but will not be restricted to coastal sediments). The sites were not evenly distributed across ~~the~~ coast, but they were representative of a variety of coastal environments, including small and large estuaries, the intracoastal waterway, harbors, industrial waterways, waste dump sites, and open waters.

Although Table **3** shows a great many concentrations above "Low" values, e.g. 6,783 or 50% of the samples, this does not necessarily represent the average contamination level of the coastal areas. In many cases, data are from surveys specifically designed to collect samples near sources of contamination. Also, it should be recognized that current conditions may not be represented in all cases. Conceivably, since the time of collection, contaminant inputs may have changed and sediments represented in COSED could have been dispersed or buried by natural processes or even dredged from the site.

The spatial distribution of COSED sites are presented in Figures **2**, **4**, and **6.** The occasional problem of incorrect latitude or longitude is illustrated in Figure **4**, where two sites retrieved from STORET and presumably from Galveston Bay, are instead plotted in Northern Texas. The majority of "5xHigh", plotted in Figures **3**, **5**, and **7**, are near cities suggesting that anthropogenic input is greater near large population centers than elsewhere. Specifically, the greatest concentrations of "5xHigh" sites were in locations with high ship traffic, industrial activity, and relatively poor water flushing, as is the case of harbors, canals, and intracoastal waterways. Such areas were more commonly sampled along the coasts of the Northeast and Gulf of Mexico than in other parts of the country. More detailed maps and an investigation of some areas of interest will follow.

The tendency for contamination to be an urban problem has been observed by many others. Laflamme and Hites (1977), for example, found that the concentration of PAH increases with proximity to urban areas. Cantillo and O'Connor (1992) showed by factor analysis that chemical concentrations at NS&T sites are strongly influenced by proximity to population centers. Exceptions to that general rule found in COSED are in parts of eastern Florida and the New York Bight, where "5xHigh" sites exist in the open waters because of nearby discharge pipes or ocean dumping sites.

Table **4**, based on mean concentrations at each site, lists the numbers of "High" and "5xHigh" sites. All 597 "5xHigh" sites are listed in Appendix **II** with the analytes exceeding the corresponding "5xHigh" value. Note that percentages of exceedances for a given chemical were calculated relative to all sites where the chemical was detected, not simply the total number of sites. Mercury exceeded the "5xHigh" level at 7.3% of the sites where it was measured, followed by cadmium (7.1%), TPAH (5.5%), tin (4.7%), and silver (3.7%), suggesting that metals are found more frequently at "5xHigh" levels. The importance of this observation is that mercury and cadmium have

a greater chance of being found at "5xHigh" levels than any of the other analytes The high frequencies with which mercury and cadmium were found at "5xHigh" concentrations also appeared in a comparison of NOAA NS&T results with data gleaned from the worldwide literature (Cantillo and O'Connor, 1992) Those authors suggested that because Hg and Cd were the elements of highest public concern, that they were frequently required to be measured in areas thought to be highly contaminated. Estimates of metal inputs into coastal waters of European signatories to the Oslo and Paris Conventions (Joint Monitoring Group, 1993), suggested that Hg and Cd were the two metals whose rates of input have been most elevated above natural rates The "5xHigh" Hg values may be of particular significance because the "5xHigh" concentration (1 1 ppm) is greater than the ER-M (0.71 ppm) thought to occurs in conjunction with biological effects.

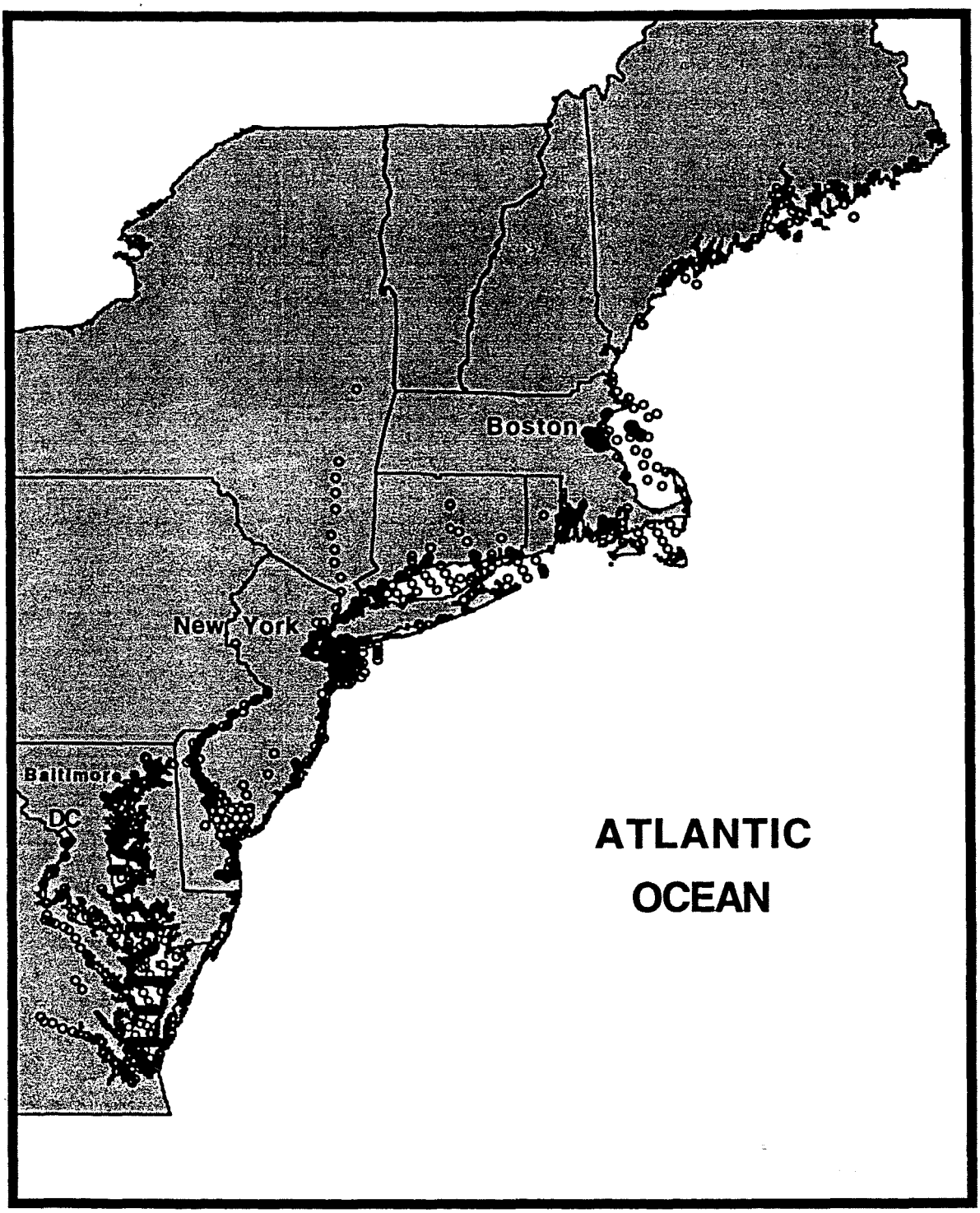


Figure 2. Sites from Northeast U.S. found in COSED.

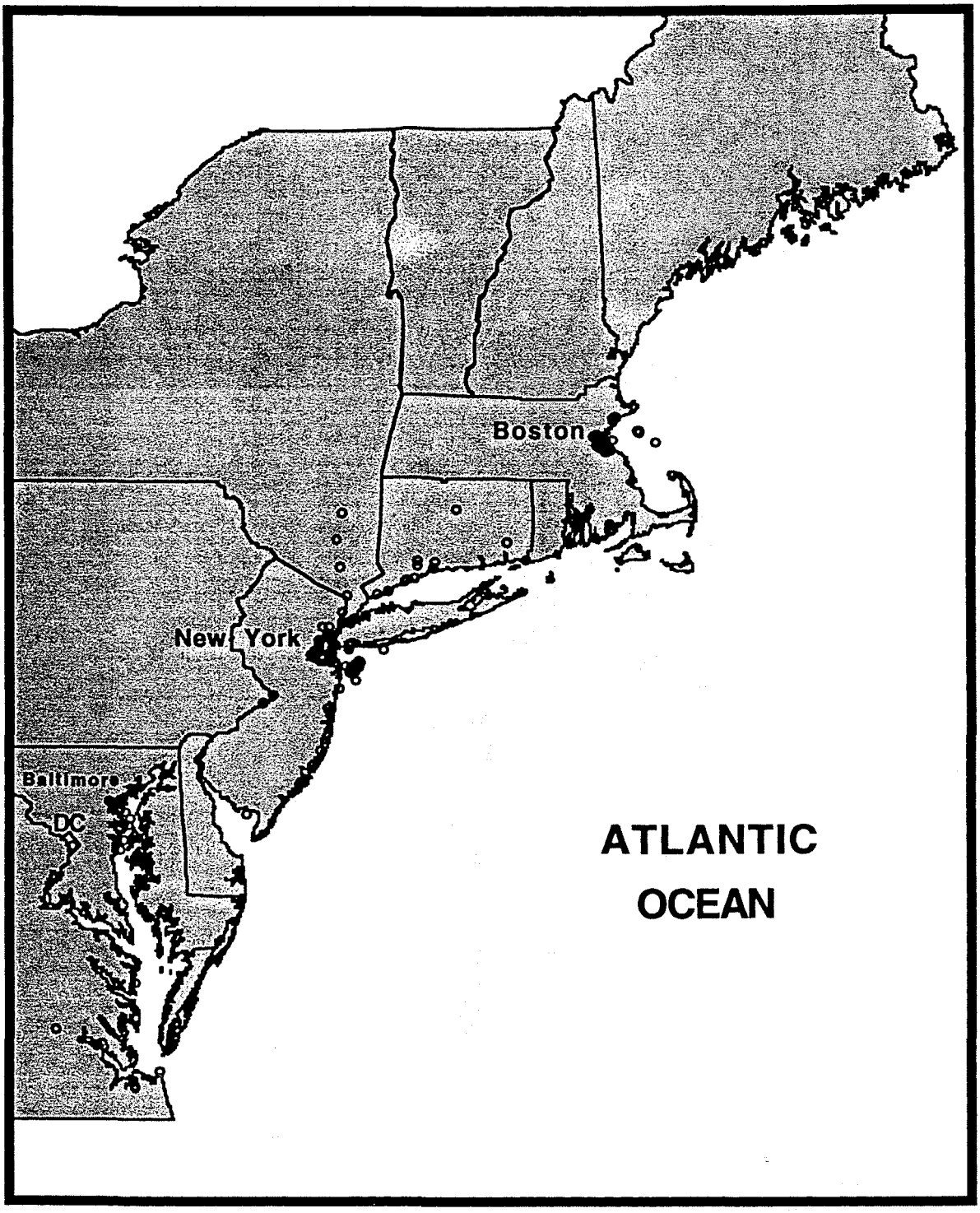


Figure 3. "5xHigh" sites from Northeast U.S. found in COSED.

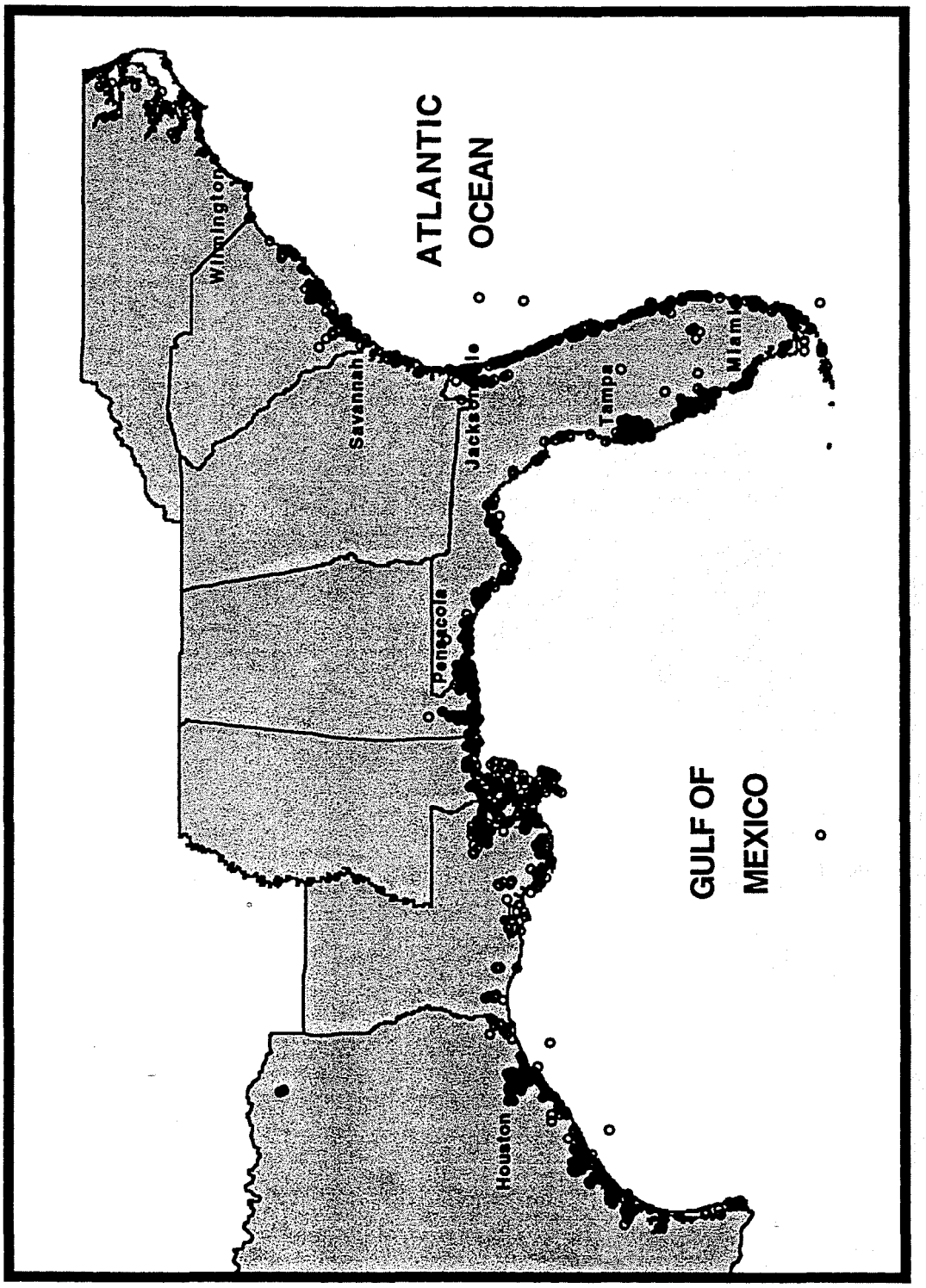


Figure 4. Sites from U.S. Southeast and Gulf Coast found in COSED.

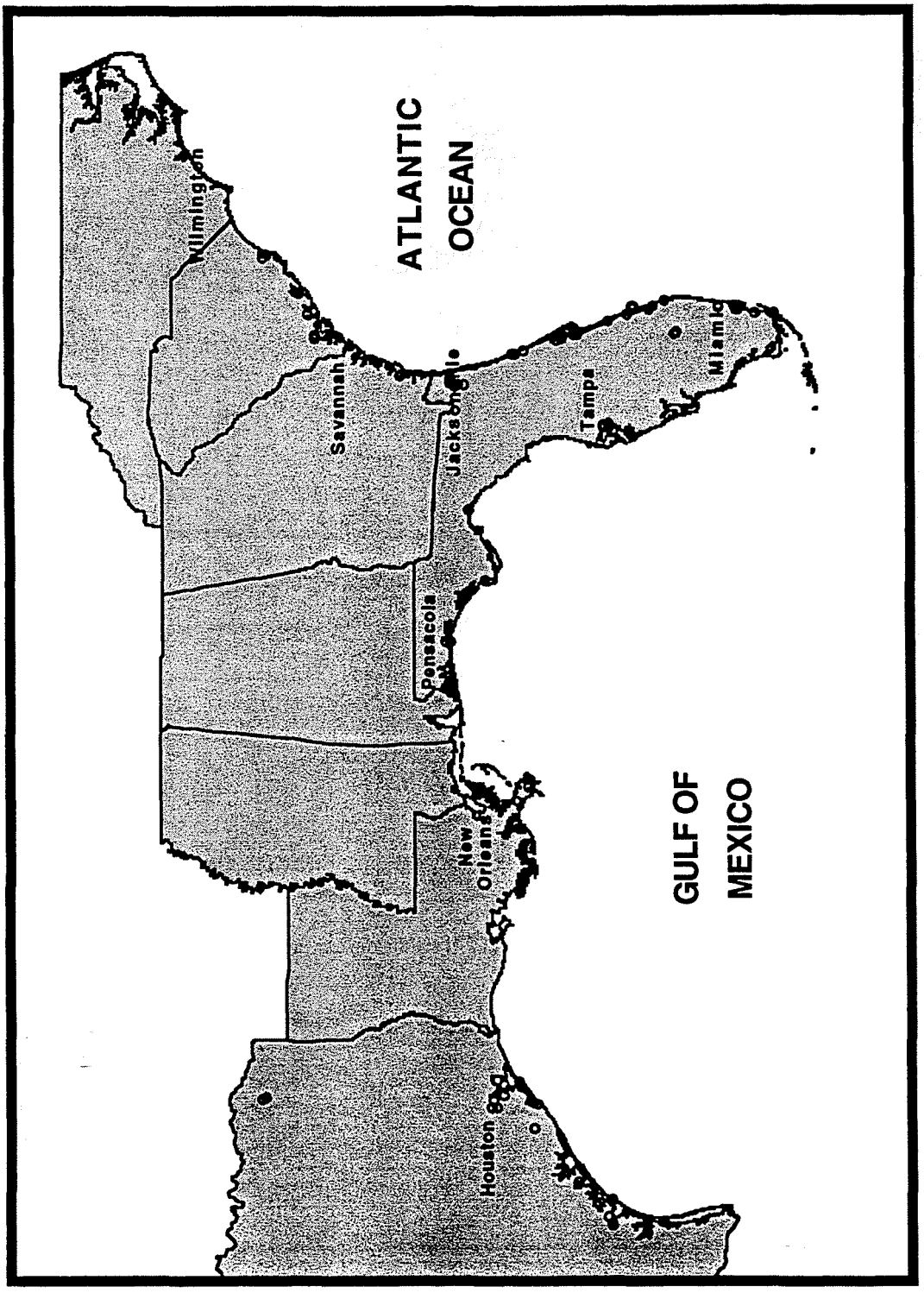


Figure 5. "5xHigh" sites from U.S. Southeast and Gulf Coast found in COSED.

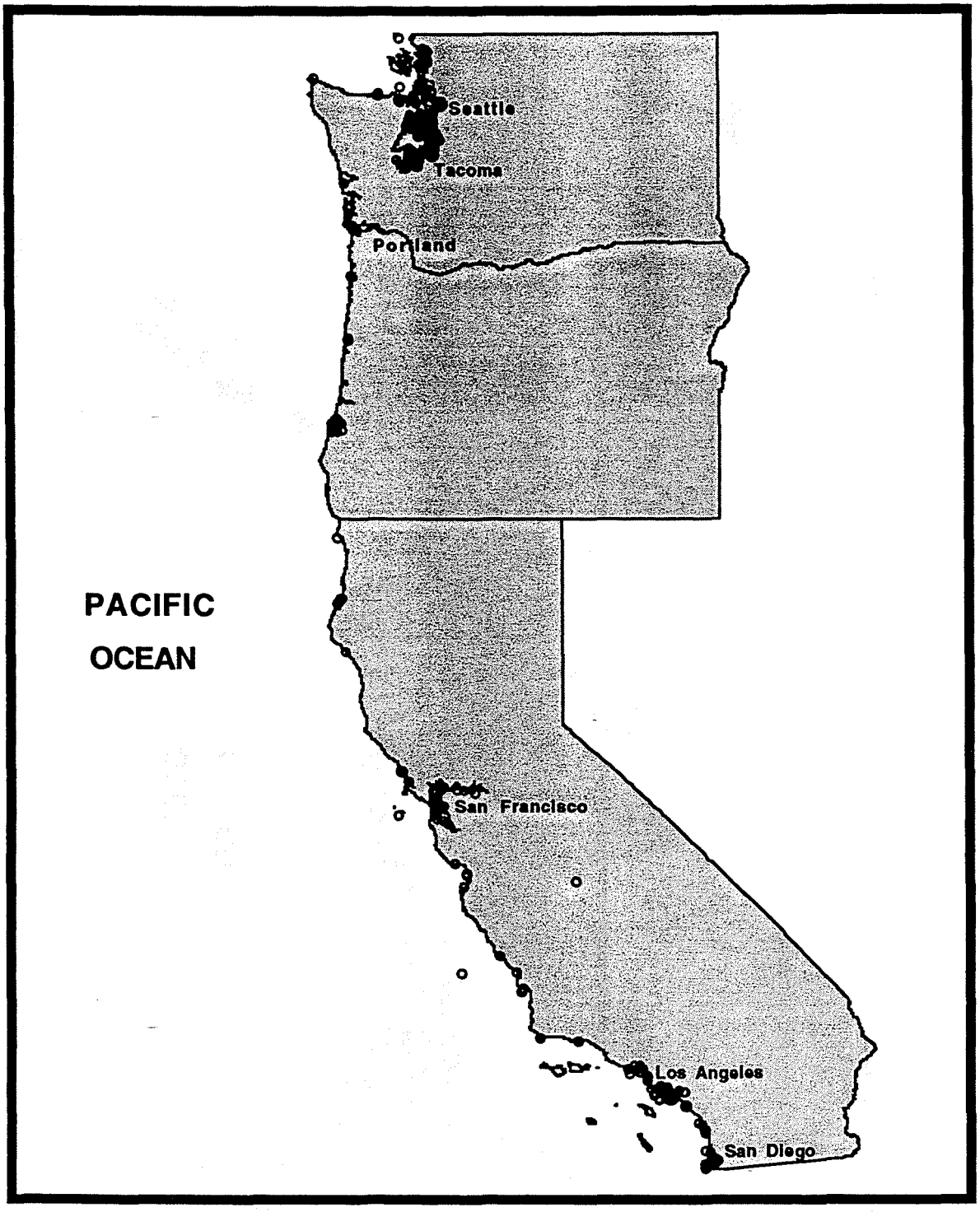


Figure 6. Sites from the U.S. West Coast found in COSED.

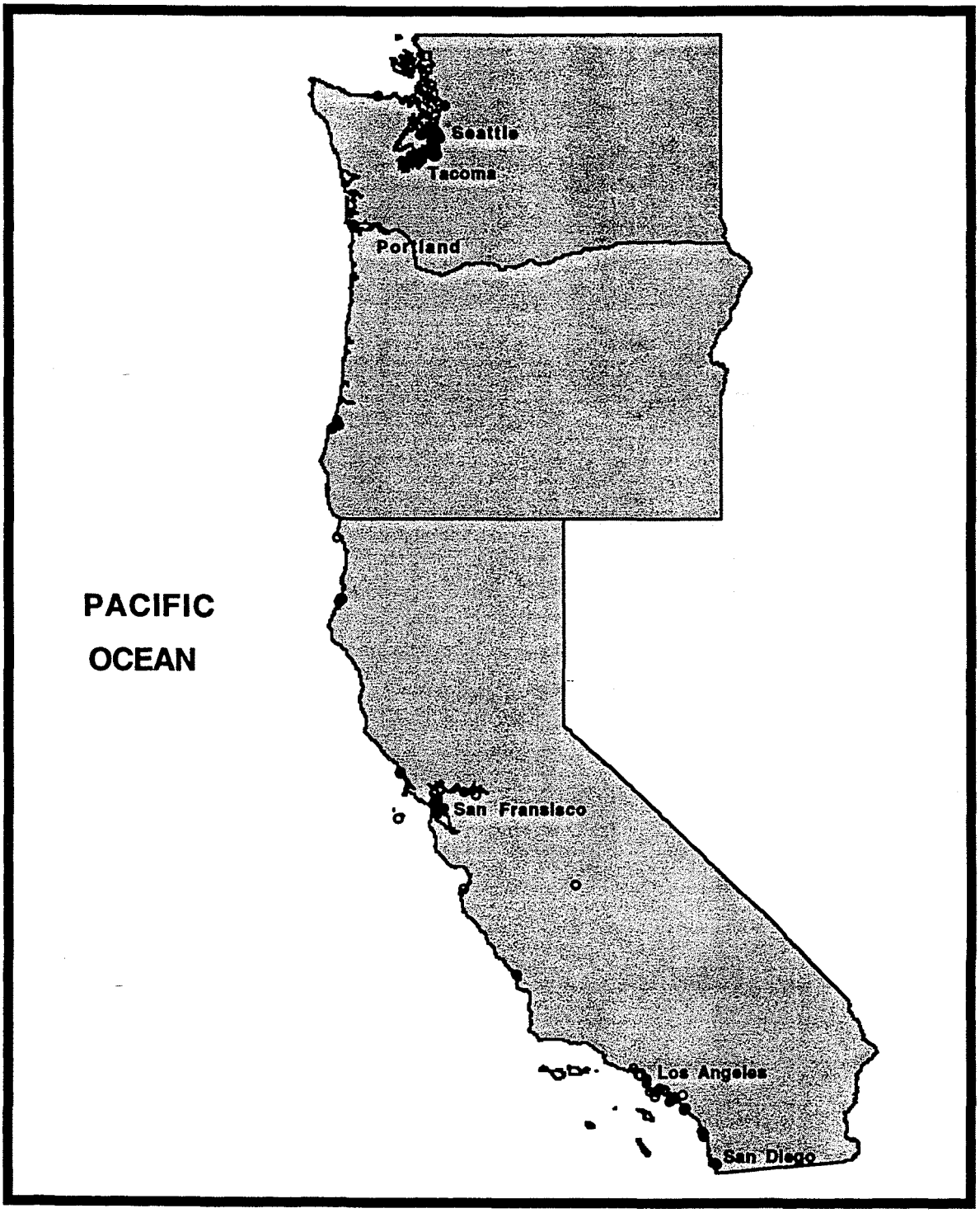


Figure 7. "5xHigh" sites from the U.S. West Coast found in COSED.

Table 4

Percentages of "High" and "5xHigh" sites in COSED

	NS[1]	"HIGH"		"5xHIGH"	
		Sites	% of Total[2]	Sites	% of Total[2]
TOTAL	3878	2154	56	597	15
Ag	2454	536	22	113	4.6
As	2399	440	18	40	1.7
Cd	3024	927	31	214	7.1
Cr	3436	380	11	26	0.8
Cu	2395	606	25	57	2.4
Hg	2885	873	30	211	7.3
Ni	3194	360	11	4	0.1
Pb	3702	847	23	110	3.0
Sb	1784	150	8.4	40	2.2
Se	1983	293	15	26	1.3
Sn	1455	295	20	68	4.7
Zn	3481	764	22	57	1.6
High MW PAH	2023	460	23	110	5.4
Low MW PAH	2011	445	22	113	5.6
Total DDT	2207	134	6.1	44	2.0
Total CHLORDANE	2012	166	8.3	37	1.8
Total DIELDRIN	2234	122	5.5	27	1.2
Total PAH	2032	471	23	112	5.5
Total PCB	1675	243	15	56	3.3

1 NS· Numbers of Sites for which sediments have been analyzed for this chemical

2 Percentage of NS

INFLUENCE OF SURVEY DESIGN

To demonstrate the influence of survey design, the frequencies of "High" and "5xHigh" concentrations are listed, respectively, in Tables **5** and **6** for each chemical in each of the 8 datasets of COSED The row labeled 'Total Sites' is the number of sites that were included in the given database. Similarly "High" or "5xHigh" Sites is the number of sites that had at least one analyte above the "High" or "5xHigh" value, respectively. The remaining rows contain the percentage of sites in which the particular analyte was above the "High" or "5xHigh" value, and were calculated with a method similar to the one used in Table **4** For example, in EMAP/EC non-random sites (second column in Table **5**) there were 8 sites with "High" Ag, out of 126 measured Ag concentrations, which is 6 3%.

The EMAP/EC random dataset contains the lowest proportion of "High" concentrations for any chemical and reflects the fact that in other datasets those frequencies are higher because the sampling schemes forced them to be. The frequency of "High" concentrations of each chemical in the NS&T/MW is about 15%, consistent with the definition of "High" values and their derivation from that dataset. The frequencies in NS&T/MW exceed those in EMAP/EC random because, even though NS&T site selection seeks representativeness, there is an urban bias. Among the 224 sites in NS&T/MW, 45% are within 20 km of 100,000 people based on 1990 census data Since it is expected and was, in fact, shown (NOAA, 1991) that chemical concentrations at sites increase with the number of people residing near a site, the NS&T/MW dataset contains more "High" concentrations than the EMAP/EC random dataset.

All the other datasets in Table **5** contain sites preselected for their likelihood to have elevated chemical concentrations. Nevertheless, while the EMAP/EC non-random dataset has larger frequencies of "Highs" than its random counterpart, it does not have higher proportions than NS&T/MW. This is because not all the non-random EMAP sites were chosen for their expected elevated contaminant levels. Some were chosen for expected low levels to test for differences in biological effects between extremes of contamination, some were chosen to test for biological effects unrelated to chemical contamination and some were chosen to lie in deposition areas. Similarly, while NS&T/BS data have more "Highs" than NS&T/MW, there are many sites within

Table 5

Percentages of "High" concentrations in COSED by dataset.

	EMAP	EMAP	SFTB	NS&T /BS	NS&T /MW	ODES	REGION4	STORET	TOTAL
Random	No	Yes	No	No	No[1]	No	No	No	
Total Sites	141	500	74	436	224	618	445	1440	3878
%"High" Sites	39	38	78	65	55	84	42	51	56
Ag	6	8	64	19	16	26	15	34	22
As	11	8	34	12	13	34	n/a	21	18
Cd	15	12	33	28	16	59	25	34	31
Cr	7	3	47	25	14	20	6	4	11
Cu	11	10	61	28	18	49	11	30	25
Hg	17	12	64	28	15	46	25	41	30
Ni	8	5	66	13	13	10	1	14	11
Pb	12	12	32	20	13	52	11	21	23
Sb	4	1	33	6	15	7	n/a	20	8
Se	11	6	23	6	14	21	n/a	32	15
Sn	14	17	57	22	12	n/a	n/a	42	20
Zn	21	17	42	29	15	35	9	20	22
High MW PAH	10	9	57	24	18	45	28	26	23
Low MW PAH	13	12	38	21	17	48	14	26	22
Total PAH	4	2	36	12	14	1	1	6	6
Total Chlordane	6	2	21	14	14	71	11	5	8
Total Dieldrin	4	1	58	7	13	10	4	2	6
Total DDT	11	9	52	24	18	46	28	26	23
Total PCB	8	5	43	37	15	0	7	9	15

1 Not random, but representative sites.
Percentages are based on number of sites analyzed for the particular chemical, a number usually less than the total number of sites.

Table 6

Percentages of "5High" concentrations in COSED by dataset.

	EMAP	EMAP	SFTB	NS&T/ BS	NS&T/M W	ODES	REGION4	STORET	TOTAL
Random	No	Yes	No	No	No[1]	No	No	No	
Total Sites	141	500	74	436	224	618	445	1440	3878
%"5xHigh" Sites	11	6.2	32.4	17	11	35	7.6	12	15
Ag	4.0	2.4	4.8	5.0	4.0	3.8	0.7	8.6	4.6
As	0.0	0.0	4.1	0.0	0.0	5.0	n/a	2.4	1.7
Cd	3.5	2.0	4.8	2.9	0.4	22	2.9	6.5	7.1
Cr	1.4	0.0	0.0	2.1	0.9	0.7	0.4	0.7	0.8
Cu	1.4	1.4	0.0	1.4	0.0	5.9	1.1	15	2.4
Hg	5.1	2.6	15	4.4	1.8	20	3.1	6.6	7.3
Ni	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.2	0.1
Pb	2.9	0.6	2.7	0.0	0.0	9.5	2.2	2.6	3.0
Sb	0.0	0.2	30	0.8	0.0	3.6	n/a	5.4	2.2
Se	0.7	0.2	0.0	0.0	0.0	1.2	n/a	5.8	1.3
Sn	4.3	1.4	0.0	3.3	0.9	n/a	n/a	24	4.7
Zn	1.4	0.6	1.4	0.2	0.0	3.9	0.5	2.3	1.6
High MW PAH	3.5	1.4	10	1.9	1.8	11	9.0	13	5.4
Low MW PAH	4.3	1.6	8.0	3.6	1.8	18	2.2	8.1	5.6
Total PAH	2.1	0.2	12	3.9	2.2	1.1	0.0	2.6	2.0
Total Chlordane	0.7	0.2	12	0.2	2.7	42	5.6	1.6	1.8
Total Dieldrin	0.7	0.0	25	0.0	0.4	5.5	1.9	0.2	1.2
Total DDT	3.5	1.4	10	2.7	1.8	12	6.7	13	5.5
Total PCB	2.8	1.2	14	8.5	2.3	0.0	2.0	1.2	3.5

[1] Not random, but representative sites.
Percentages are based on number of sites analyzed for the particular chemical, a number usually less than the total number of sites.

that dataset that were chosen to be representative rather than particularly contaminated For the SFTB, ODES, Region4, and STORET datasets there is no information to indicate the motivation for site selection. We know that some of the SFTB and Region4 sets contain data from files of the U.S Army Corps of Engineers that was collected in the context of dredging slips and piers and is therefore likely to be fairly contaminated. We know that STORET and ODES contain data collected in the context of compliance monitoring of point sources of chemical discharges. The information, however, needed to sort through those datasets to extract what might be considered data that represents background conditions, is not readily available.

It must be recognized that the COSED database cannot be used simply as a collection of numbers that, in the aggregate, define the extent of sediment contamination in the coastal United States If it were simply used in that fashion, it would give the impression that elevated levels of contamination are common throughout the coastal nation. That would be wrong because many of the datasets embedded within COSED are biased, by site selection, towards elevated concentrations. Table **6** corresponds to Table **5** except that frequencies were calculated for "5xHigh" sites rather than "High" ones The same types of bias are still evident, but, because frequencies of "5xHigh" concentrations are generally low, they do not show as much difference between datasets as do the frequencies of "High" concentrations.

The 597 "5xHigh" sites listed in Tables **3** and **4** are not distributed evenly along the coastal U S , rather, they are clustered in relatively small areas. Approximately 50% of them are located in just three places. Boston Harbor, Southern California, and Puget Sound (see Appendix III). The New York Bight has also been sampled extensively over the years, and 40 "5xHigh" sites are in this locality, while more than 20 "5xHigh" sites are located in San Francisco Bay. Excluding the above 300 "5xHigh" sites, the remaining 180 are clustered into smaller groups and distributed along the coastal line. This is demonstrated in the last two columns of Appendix **II**, examination of which reveals that most "5xHigh" sites have several other neighboring "5xHigh" sites within a 10 km radius.

AREAL EXTENT OF CHEMICAL CONCENTRATIONS

Converting COSED to an estimate of the areal extent of chemical concentrations is, in principle, possible The procedure would be to lay a grid of squares (or any shape) over a map of the U S coast and, using COSED, assign concentrations for each chemical to each square within the grid. The coastal area with Cu concentrations $\geq$ 50 µg/g, for example, would be the sum of areas of squares with assigned concentrations $\geq$ 50 µg/g. However, two considerations argue against doing that. First, it would be computationally tedious because the size of the squares would have to change with location as the spatial density of the sites changed. Squares could be very small where COSED has many records over small spatial scales. Squares would need to be very large, on the other hand, where data are sparse The second reason for not attempting this spatial analysis is because the EMAP/EC Program was designed specifically to provide statistically rigorous estimates of environmental conditions on a spatial basis. It is unnecessary to try to extract information from COSED that EMAP/EC is already providing

The EMAP/NC Program sampling design is based on a grid pattern of hexagons that is mapped onto the coast prior to any data collection Sampling sites are chosen by randomly selecting hexagons. A central assumption is that, in the aggregate, it is possible to calculate the areal extents of every attribute measured in each hexagon It is never assumed that the attribute, i e , Cu concentration, measured at one site in the hexagon represents the mean for the entire hexagon. It is argued that over large regional scales encompassing many hexagons, that one can use the data to calculate the percentage of area with Cu concentrations in a given range We can combine all the EMAP data in COSED that is from randomly selected sites to calculate cumulative fractions of total estuarine area in the combined Virginian and Louisianian Provinces that is covered with sediment at concentrations below any given value. Figure **8** is the result of that calculation for Cu and shows, for example, that over 90% of the total estuarine area in those combined provinces has surface sediment with concentrations less than 50 µg/g

Table **7** lists the percentage of area that exceeds the "high" concentration for each chemical. The percentages are less than those in the corresponding column in Table **5** because not every concentration in the EMAP/EC-random dataset is associated with the same size area. All concentrations from large estuaries are from randomly selected 280 km^2 hexagons but there are also randomly selected small

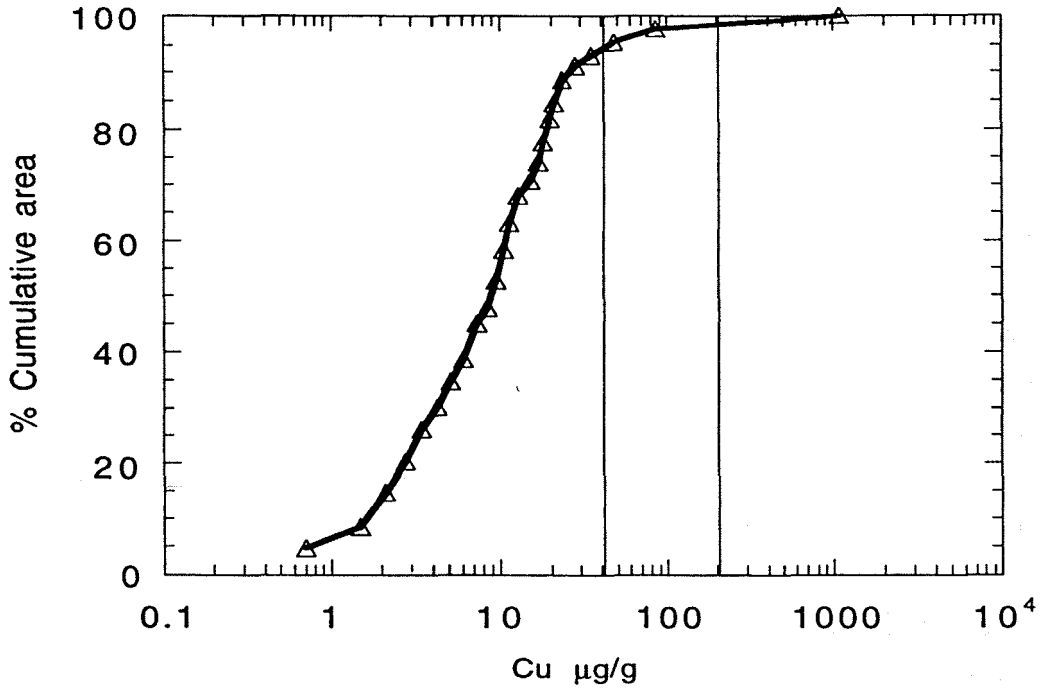


Figure 8. Cumulative estuarine area in combined Virginian and Louisianian Provinces as a function of Cu concentration (µg/g dry) in sediment. The two vertical lines represent the "High" (lower concentration) and "5xHigh" (greater concentration) from the NS&T/MW dataset.

estuaries and tidal rivers that have smaller and, unique areal extents in the range of 1 to 270 km^2.

The EMAP data are ideal for making these types of areal estimates over large regions of the country. At the moment, there are no EMAP data for the Southeast, the West Coast, or the Northeast Coast from Cape Cod to Canada. When these Provinces have been sampled, it will be possible to construct tables and figures of cumulative areas on a national scale.

Table 7

EMAP % area above "High" or "5xHigh"

Analyte	"High"	"5xHigh"
Ag	1.3	0.1
As	7.3	0
Cd	4.5	1
Cr	1.5	0
Cu	5	1.4
Hg	6.8	1.2
Ni	1.9	0
Pb	6.1	0.3
Sb	1.2	0.7
Se	4.4	0.7
Sn	10.7	1.5
Zn	9.3	0.3
High MW PAH	1.6	0.4
Low MW PAH	4.4	0.7
Total Chlordane	1.2	0.5
Total DDT	0.3	0
Total Dieldrin	0.1	0
Total PAH	2.7	0
Total PCB	1.2	0.2

With more data, Figure **8** will shift to the right or left but it is unlikely that concentrations of Cu, or any other chemical, corresponding to "5xHigh" or ER-M (210 and 270µg/g, respectively) concentrations will account for more than a very small portion of the total coastal area. Cumulative plots for all contaminants from EMAP data have been calculated in Appendix **III**, and it was observed that in all cases only a small percentage of the area had concentrations above the "5xHigh". This simply reiterates the theme that extreme concentrations are of limited spatial extent.

"HIGH" CONCENTRATIONS AND CONTAMINATION

The analysis of COSED has been based on raw data because the majority of records have no entries for aluminum, iron, grain-size, or total organic carbon that might have been used to adjust concentrations for their natural components It is worth investigating, however, whether "High" concentrations are due to contamination and not natural factors.

Because they are associated with surfaces, concentrations of trace chemicals in sediment tend to increase as particle size decreases Even under pristine conditions there will be a range of trace element concentrations that roughly parallels the portion of fine-grained particles in a sediment sample One way of accounting for this effect is to "normalize" trace concentrations against the concentrations of a major element whose concentration also increases as particles become smaller Candidates for this major element have been aluminum (Goldberg et al , 1979, Windom et al , 1989; Hanson et al , 1993), iron (Kennicutt et al, 1994), and lithium (Loring, 1990) The basic idea of all these authors has been to establish the "natural" relationship of the minor to major element by regression over a range of concentrations in sediments known *a priori* to be free of contamination (e.g. Cu=mAl+b where m and b are the slope and intercept, respectively, of a linear regression). With the relationship established for each trace element, contamination can then be declared to exist when a concentration is found that exceeds the predicted "natural" value. This approach assumes that the major element concentration is too high to be affected by human activity, and that the samples selected for establishing the relationship are unaffected by humans This selection is to some extent subjective, but is generally valid based as it is on sites that are far from industrial sources of contamination

Within all of COSED, 99% of the Al concentrations are less than 10% (10,000 ppm-dry) and 99% of the Fe concentrations are less than 6% (6,000 ppm-dry). In Table **8,** some of the relationships that have been established were applied to the "High" concentrations to calculate the corresponding concentration of aluminum or iron. For all elements, except As, it is clear that "High" concentrations are beyond the range where they can be considered natural.

Since all the relationships used in Table **8** are entirely or predominantly based on pristine sites in the Southeast and Gulf coasts, it must be recognized that the

Table 8

Normalization Parameter Concentrations for "High" to be Consistent with Natural Levels

		Al%[1]	Al%[1]	Al%[2]	Fe%[3]
	NS&T/MW "High" /ppm	GA/SC	Florida	East-Gulf	East-Gulf
Ag	0.52			*58.*	
As	13		1.8	8.6	3.9
Cd	0.54			*27.*	
Cr	125		13	14	7.3
Cu	42	24	16	21	11
Hg	0.22			*21*	
Mn	875	15	18	*9..5*	4.5
Ni	42	10	14	13	6.6
Pb	45	12	13	14	7.8
Se	0.92			*19.*	
Sn	4.0			10	6.3
Zn	135	12	11	11	5.8

Numbers in italics denote low correlation coefficients in the linear models.

[1] Windom et al (1989).

[2] Hanson et al (1993).

[3] Work in progress by the authors

natural concentrations in other parts of the United States may be higher than predicted by the equations behind Table 8. It should also be recognized that the correlation coefficients for those equations are weak (i e less than 0.3) for Ag, Cd, Hg, and Se. Nevertheless, while absolute certainty does not apply in every case, it does appear that "High" concentrations do not occur naturally Concentrations above "5xHigh" are certainly due to contamination.

CHEMICAL CONCENTRATIONS AND TOXICITY

The central reason for interest in chemical concentrations is not for their own sake, but because there should be a connection between them and biological effects. Those effects, not the chemicals themselves, are the problem. Converting the areal estimates of chemical concentrations to the areal extent of the problem requires a basis for selecting concentrations of concern.

If the ER-M concentrations of Long et al. (in press) actually correspond to concentrations above which biological effects can be expected, then the frequencies of "5xHigh" concentrations might parallel the occurrences of biologically effective concentrations, since the ERM concentrations are within a factor of two of "5xHigh" (Table **2**). The EMAP dataset provides a test of this possibility because results of chemical analyses are accompanied by an estimate of whether the sample was toxic. A sample was declared toxic if there was less than 80% survival of amphipods during ten-day exposures. Unfortunately, Table **9** shows that chemical concentrations are not particularly strong predictors of toxicity. The frequency of toxicity does increase with concentration, but concentrations in the highest range (either "5xHigh" or ER-M depending on chemical) do not correspond to more than about a 50% frequency of toxicity and, concentrations in the lowest range (below "High" or ER-L) still test as toxic in about 15% of the cases. For some chemicals, there are fewer than ten samples with concentrations in the highest range and no percentages were calculated.

While measures of toxicity based on bioassays do not lead to useful connections between concentration and effects, it does appear that observations of actual effects of chemical contamination among indigenous organisms is limited to urban areas where concentrations are very high. Therefore, while the spatial extent of chemical concentrations on large scales can be quantified from EMAP/EC data and on estuarine scale with the use of the rest of COSED, chemical data corresponding to biological damage among indigenous organisms needs to be collected through directed sampling over relatively small scales.

Table 9

Toxic/total and percentages of toxic sites for all EMAP sites with concentrations[1] per chemical in various categories.

	≥ER-M	≥"5xHigh"	≥"High"	≥ER-L	<"High"	<ER-L
	Toxic /Total	Toxic /Total	Toxic /Total	Toxic /Total	Toxic /Total	Toxic /Total
Ag	5/9	6/10	11/31	10/22	64/438	65/448
As	0/0	0/0	7/47	21/130	69/421	55/338
Cd	2/2	5/12	20/58	15/35	65/527	70/550
Cr	3/3	2/2	9/13	19/76	82/595	72/532
Cu	3/3	4/4	19/50	21/73	74/557	72/534
Hg	13/28	8/14	20/63	36/125	72/512	56/450
Ni	7/15	0/0	11/33	49/245	79/560	41/348
Pb	5/6	4/4	21/62	21/64	72/540	72/538
Zn	7/13	2/5	23/84	23/87	70/526	70/523
High MW PAH	7/11	6/10	20/46	21/54	70/537	69/529
Low MW PAH	5/10	5/10	22/60	24/65	69/534	67/529
Total PAH	2/4	6/10	19/45	16/35	72/549	75/559
Total DDT	5/8	3/3	7/10	46/158	65/437	26/289
Total PCB	8/15	4/5	10/21	23/82	68/487	55/426
	%toxic	%toxic	%toxic	%toxic	%toxic	%toxic
Ag		60	35	45	15	15
As			15	16	16	16
Cd		42	34	43	12	13
Cr			69	25	14	14
Cu			38	29	13	13
Hg	46	57	32	29	14	12
Ni	47		33	20	14	12
Pb			34	33	13	13
Zn	54		27	26	13	13
High MW PAH	64	60	43	39	13	13
Low MW PAH	50	50	37	37	13	13
Total PAH		60	42	46	13	13
Total DDT			70	29	15	9
Total PCB	53		48	28	14	13

[1] Concentrations marking categories are listed in Table **2.**
%Toxic were calculated only when total samples were more than ten.

SPECIFIC CASES

While COSED was developed to provide a national assessment, there are sufficient data to define extents of contamination on estuarine scales Tables **10-14** provide the total number of samples and sites in five specific regions, along with numbers of sites where mean concentrations exceed "5xHigh" levels. Figures **9-14** are maps where sites are plotted as "Low", "High", or "5xHigh" depending on contaminant levels. In addition, all "5xHigh" sites are presented in Appendix **II**, along with all the contaminants over "5xHigh" level, and the number of "5xHigh" sites within a 10 or 20 km radius

Boston Harbor

MacDonald (1991), using sediment and tissue data collected by various surveys at 448 separate stations, concluded that contamination was widespread in biota and sediments. COSED data yielded the same conclusion As seen in Figure **9**, almost all the stations had high levels of contamination, even when they were located outside the harbor. Along with Long Island Sound and New York Bight, this is one of only three cases in our database that almost every sediment sample exceeds the "High" level. Within the harbor, levels of contamination were higher in the North side as seen by the number of the "5xHigh" stations, as seen in Table **10**. Metals, in particular Hg, Cd, and Pb were the most commonly found contaminants throughout the harbor, with Hg being present at above "5xHigh" levels at over 60% of the sites The highest levels of pollutants were found in the enclosed waterways, e.g. the Mystic River

Table 10

Total number of sites in Boston Harbor with at least one chemical at "5xHigh" levels, and total concentrations per chemical

Total	150
"5xHigh"	109
Ag	13
Cd	55
Cu	14
Hg	96
Pb	29
Sb	1
Sn	7
Zn	6
High MW PAH	1
Low MW PAH	3
Total DDT	1
Total PAH	1
Total PCB	5

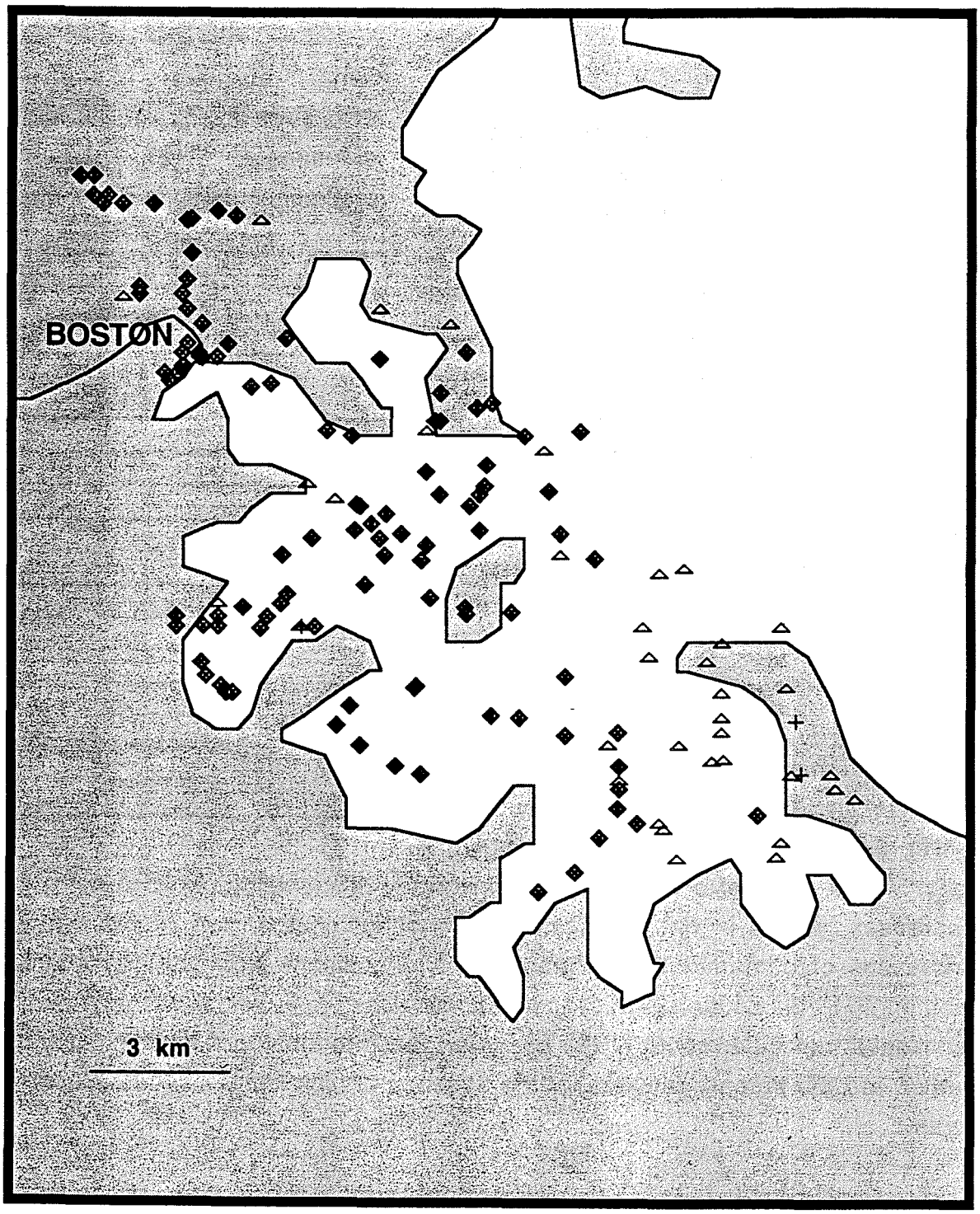


Figure 9. Boston Harbor sites included in COSED. Sites have been divided into "Low" (crosses), "High" (triangles), and "5xHigh" (diamonds) categories, based on NS&T/MW "High" concentrations.

Chesapeake Bay

There is a large number of sampling sites throughout the Chesapeake Bay, as seen in Figure **10**. The majority of the sites in the middle and lower bay have low levels of pollutants, while contaminated sediments are more common in the upper bay. A few "5xHigh" spots were found in the Chesapeake Bay, mostly in Baltimore harbor, with one each in Norfolk harbor; James River; lower, middle, and upper bay; and Washington D.C. (Anacostia River). However, these are small areas that should not alter the overall picture, and apparently do not contribute great levels of contamination to the bay Higher concentrations of chemical substances in the upper estuary are attributed to natural and anthropogenic sources alike. The major supplier of fresh water is the Susquehanna River, discharging into the northern part of the bay. Scavenging of dissolved contaminants by precipitating particles as the salinity increases results in fine sediment accumulation in this part of the estuary and increases of contamination Atmospheric depositions from the city of Baltimore contribute to the contaminant concentrations in the upper part of the bay, too. Sandy sediments near the mouth of the bay, along with the influx of relatively clean ocean water, are the primary reasons for the absence of high levels of contaminants in this area.

Table 11

Total number of sites in Chesapeake Bay with at least one chemical at "5xHigh" levels, and total concentrations per chemical.

	Sites
Total	370
"5xHigh"	24
Ag	5
Cd	8
Cr	1
Cu	8
Hg	1
Pb	2
Sb	2
Se	2
Sn	10
Zn	9
High MW PAH	3
Low MW PAH	8
Total PAH	4
Total PCB	3

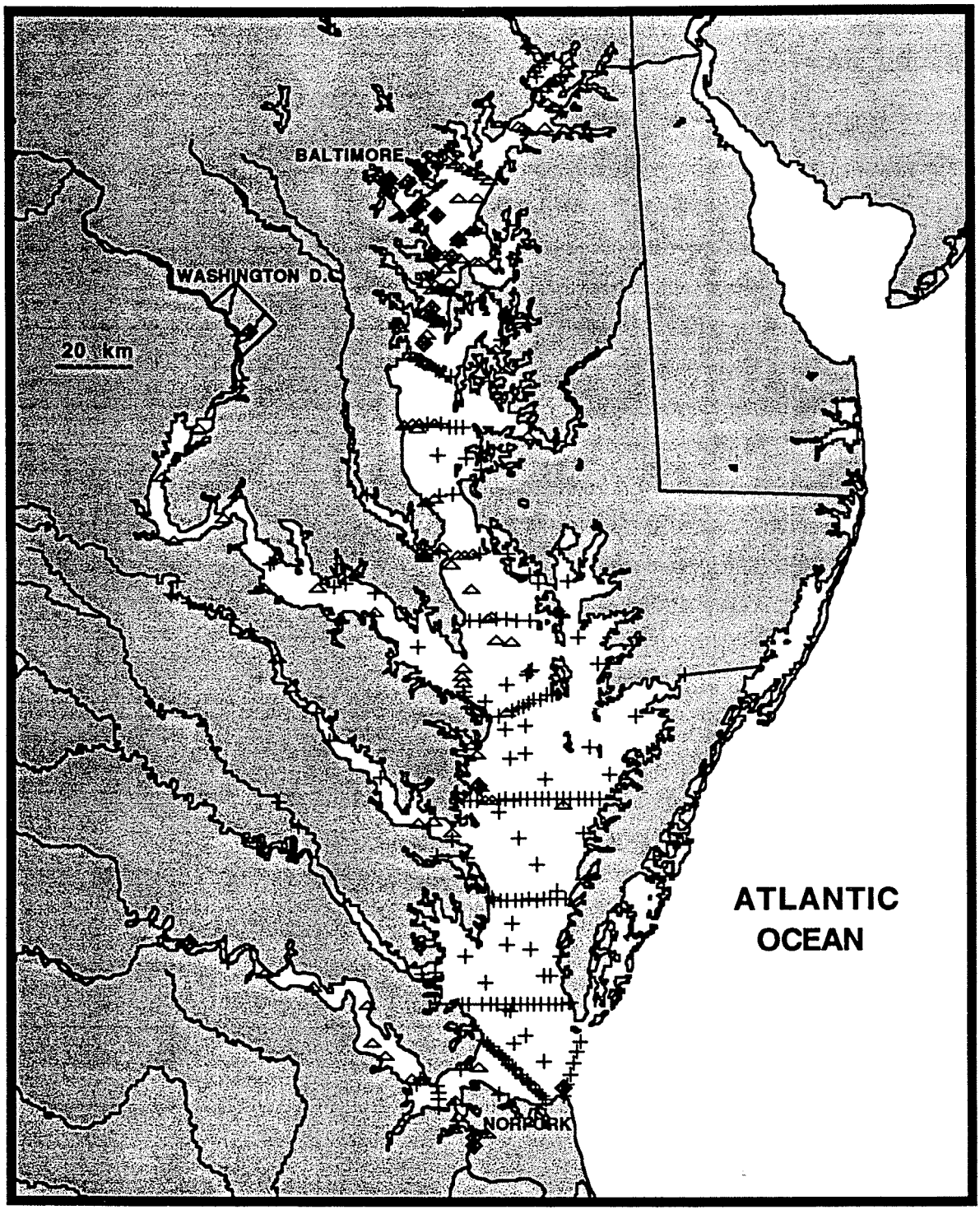


Figure 10. "Low" (crosses), "High" (triangles), and "5xHigh" (diamonds) sites from Chesapeake Bay included in COSED.

Tampa Bay

Table 12

Total number of sites in Tampa Bay with at least one chemical at "5xHigh" levels, and total concentrations per chemical.

	Sites
Total	125
"5xHigh"	11
Cd	7
Cu	1
Hg	3
Pb	3
Zn	1
High MW PAH	2
Low MW PAH	2
Total Chlordane	4
Total DDT	2
Total Dieldrin	3
Total PAH	2
Total PCB	4

Tampa Bay is characterized by chemical concentrations that vary strongly with location In agreement with Long et al (1991), the highest levels of contamination are found throughout Hillsborough Bay, and most of the "5xHigh" spots are located in the inner part of this bay (Figure **11**). Two more "5xHigh" sites and two "High" sites are located in the Manatee River, along with several low-level sites Exceptions to the general rule are several sites with "High" concentration levels in the middle Tampa Bay area. Old Tampa Bay appears to be relatively clean, but limited number of stations there, and also in Boca Ciega Bays, make any conclusion difficult. In contrast to other highly contaminated areas, "5xHigh" spots in Tampa Bay do not have contaminant concentrations reaching extreme levels Cadmium was the most common contaminant, and was present in seven sites Pesticides and other organic contaminants were found occasionally in Tampa Bay, as seen in Table **12**.

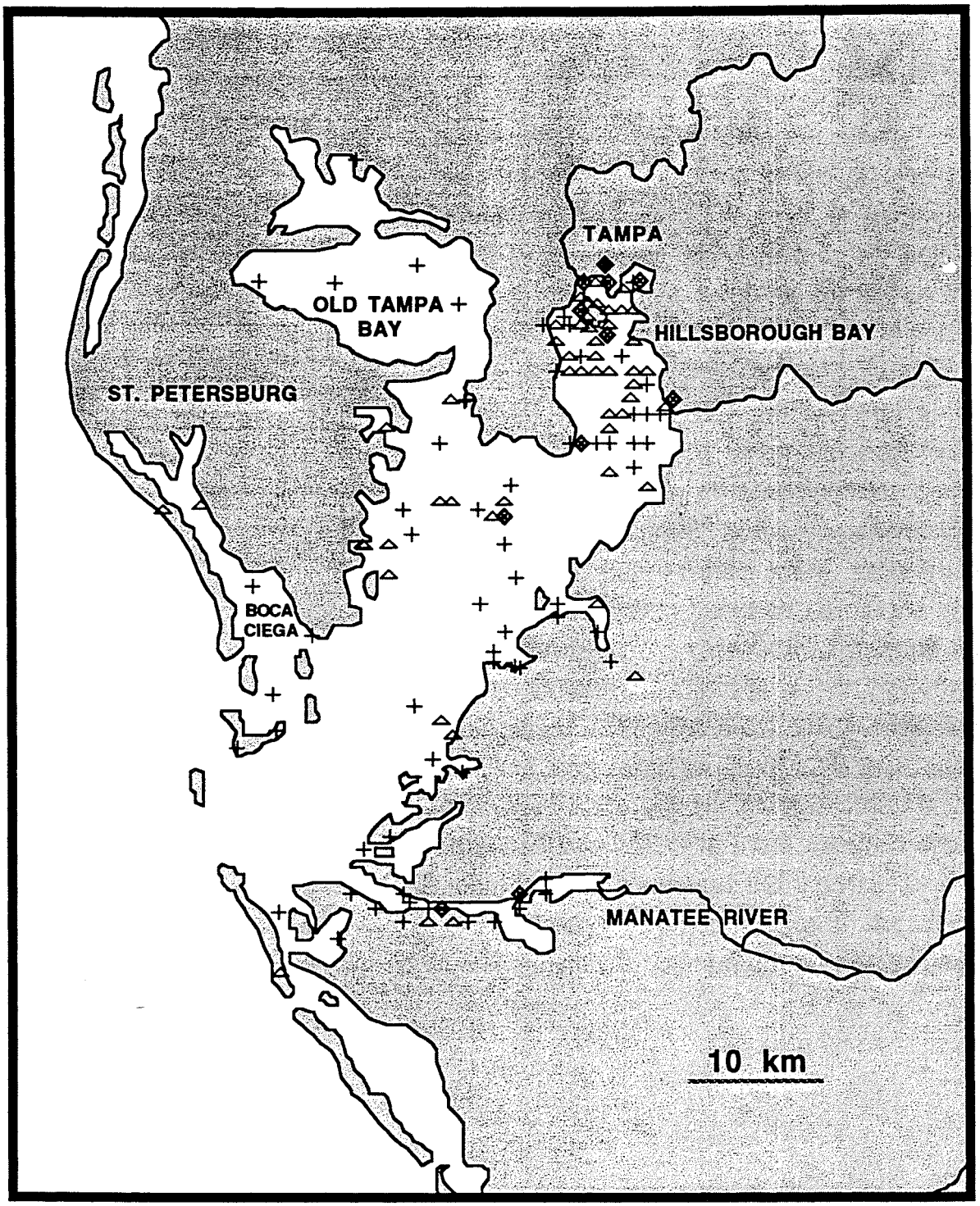


Figure 11. "Low" (crosses), "High" (triangles), and "5xHigh" (diamonds) sites from Tampa Bay appearing in COSED.

Santa Monica & San Pedro Bay.

There are several "5xHigh" sites along the coastal line of southern California in our database, as seen in Figure **7**. Specifically, in San Pedro and Santa Monica Bays there are numerous samples of high contaminant concentration. Besides the sites near the coast, we find "5xHigh" sites as far as 12 miles out into the Gulf of Santa Catalina Pesticides are some of the most frequently found contaminants, in particular total DDT, which was present at "5xHigh" levels at 20% of the sites. Many samples were "5xHigh", but one should be cautious in interpreting these findings as widespread contamination Although there are 1726 samples in the database, there were only 142 unique sites, thus many sites were sampled tens of times. Over 1200 samples, i.e. the great majority of these samples, were 301h sewage discharge program samples, from 53 sites. There are 49 "5xHigh" Cd samples, but all of them are located at 4 sites, as can be seen in Table **13**. Since, in some reports, the unique locations may not be given, statistics based solely on the number of samples should be viewed with skepticism.

Table 13

Total number of sites in Southern California with at least one chemical at "5xHigh" levels, and total concentrations per chemical

	Sites
Total	142
"5xHigh"	46
Ag	4
Cd	4
Cr	1
Cu	1
Hg	3
Sb	1
Se	1
Sn	11
Tl	12
Total Chlordane	3
Total DDT	20
Total Dieldrin	2

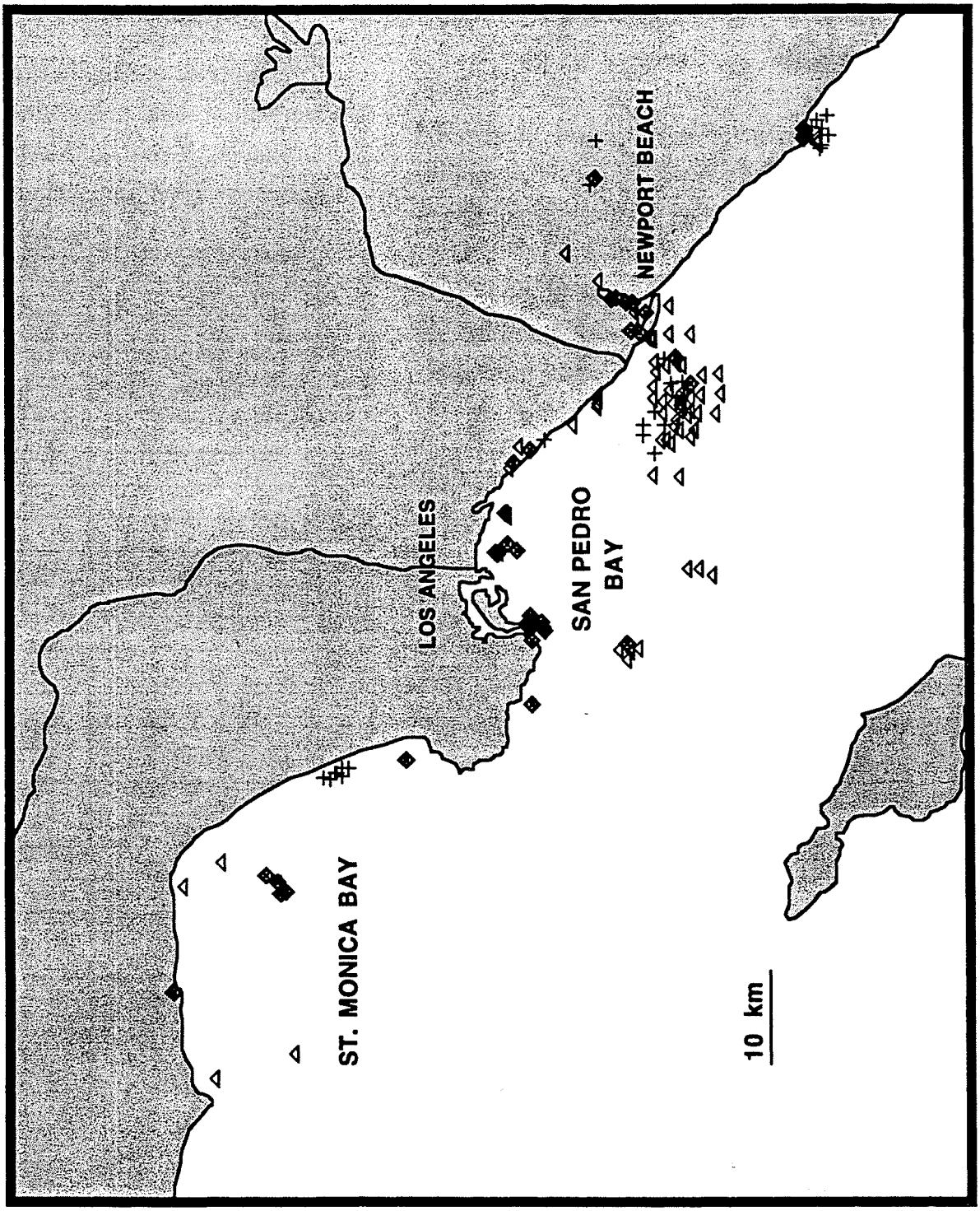


Figure **12.** Sites from Southern California divided in "Low" (crosses), "High" (triangles), and "5xHigh" (diamonds) as explained in the text.

Puget Sound

Data from a large number of stations have been found for Puget Sound, mainly located in Inlets and Bays, as seen in Figures **13** and **14a-b** Over 30% of the sites exceeded the NS&T "High" concentrations for Pb, although Cd was the most commonly found element at the "5xHigh" level, followed by PAHs, Pb, As, and Cu Most of the "5xHigh" cases were found in Commencement Bay and Duwamish waterway Other areas of concern were in Bainbridge island, Sinclair Inlet, and Case Inlet In general, although Puget Sound appears to be heavily contaminated, it is the region between Commencement Bay and Bainbridge Island that bears the majority of the contaminated sites with the remaining bay being moderately contaminated. Previous works support these results for example, Paulson et al (1989) determined that high concentrations of dissolved Cd, Cu, Pb, and Zn were emitted from anthropogenic sources, shipyards, and other industrial areas, in Elliott Bay and the Duwamish Waterway A smaller number of samples from COSED, in the Hood Canal, indicate relatively clean sediments in this area

Table 14

Total number of sites in Puget Sound with at least one chemical at "5xHigh" levels, and total concentrations per chemical.

	Sites
Total	634
"5xHigh"	135
Ag	5
As	23
Cd	63
Cu	14
Hg	7
Ni	1
Pb	28
Sb	10
Se	3
Sn	17
Tl	1
Zn	13
High MW PAH	51
Low MW PAH	58
Total Chlordane	2
Total PAH	55
Total PCB	1

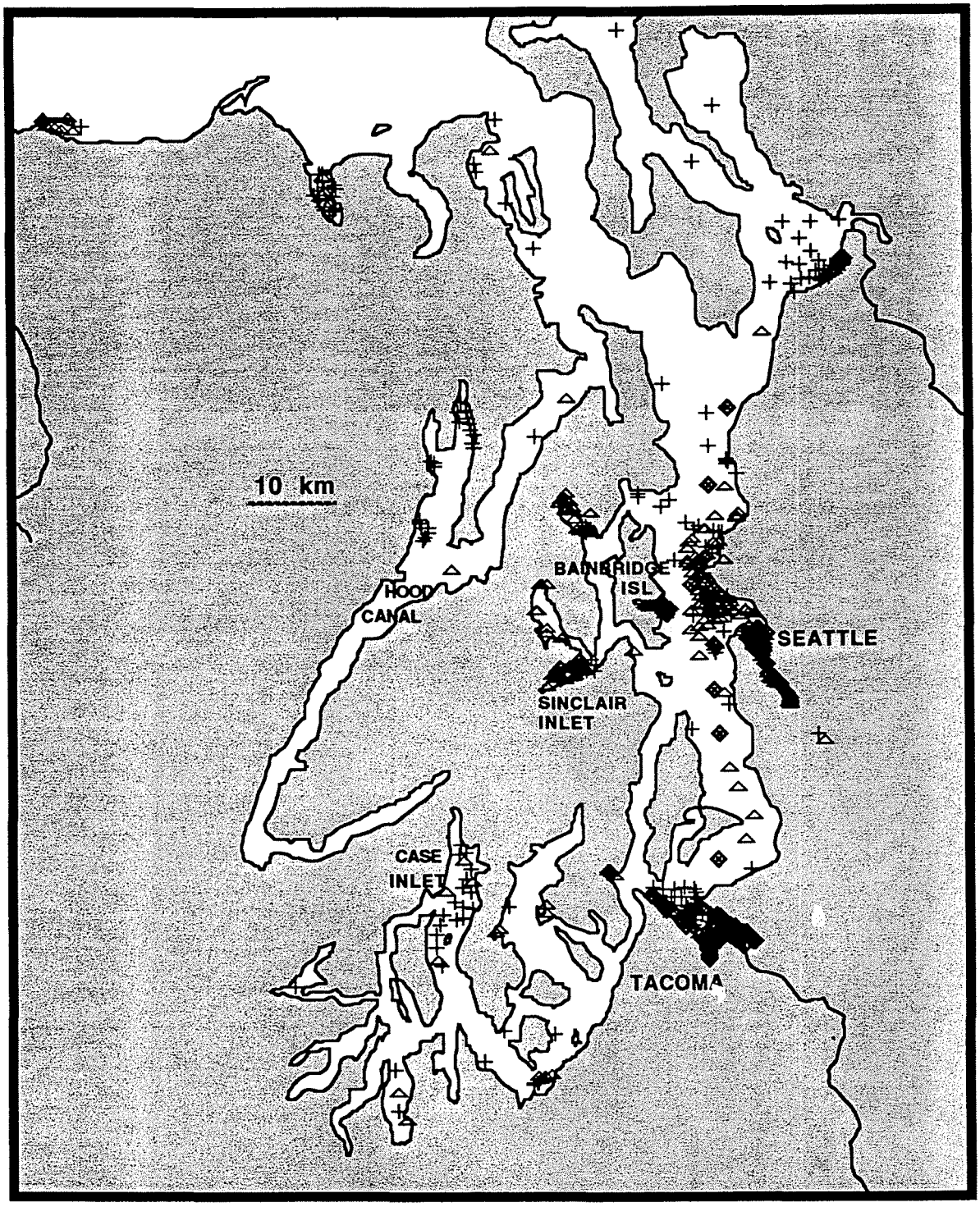
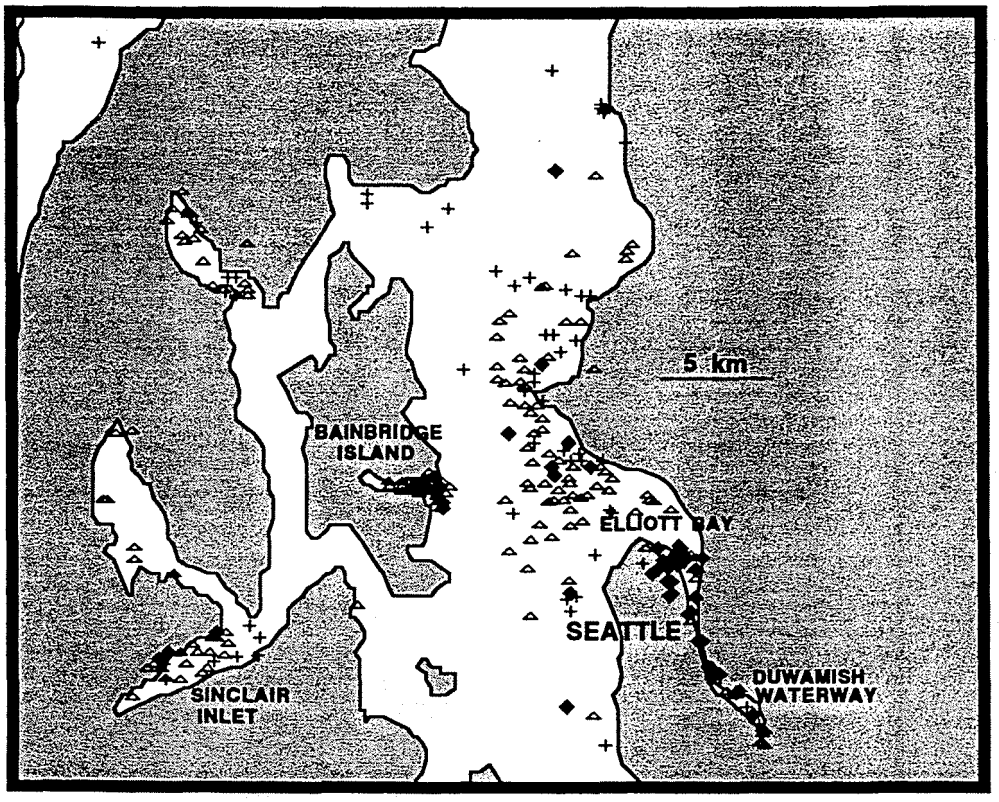
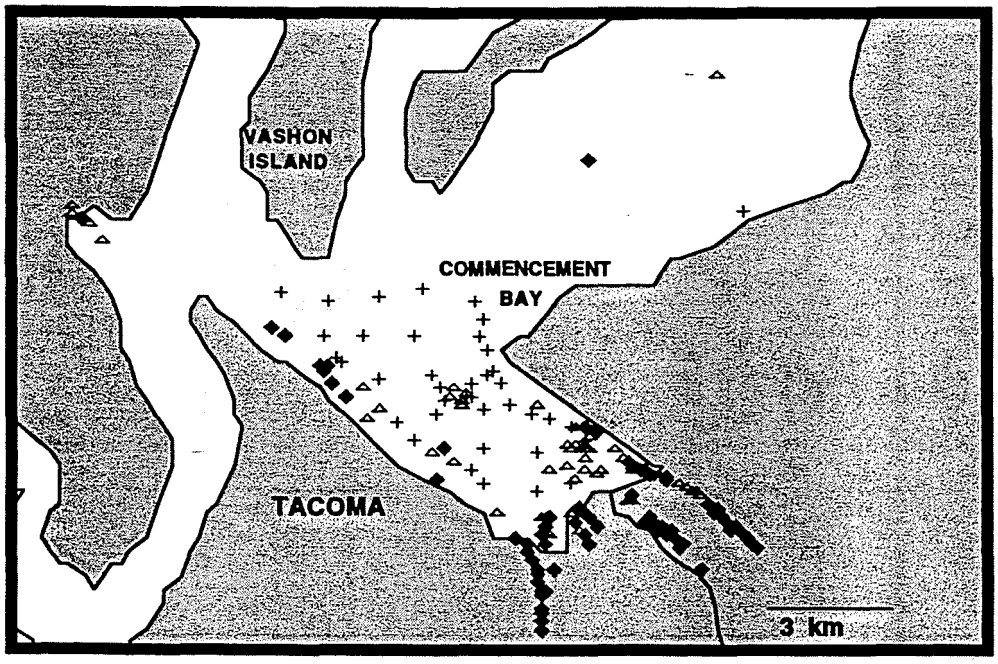


Figure 13. Puget Sound sites included in COSED categorized as "Low" (crosses), "High" (triangles), and "5xHigh" (diamonds).



(a)



(b)

Figure 14. Details of Puget Sound sites included in COSED: a) Seattle area, and b) Tacoma and Commencement Bay.

CONCLUSIONS

COSED has been compiled for sediment chemistry in the coastal U.S. The data reveals a number of sites with contaminant concentrations above "5xHigh" levels (five times the NS&T "High" value). Two general conclusions can be drawn from this work:

- Most of the "5xHigh" sites were located near large cities, suggesting anthropogenic sources for these contaminats.

- The spatial scale of contamination varies depending on location, but in general, it appears that smaller water bodies with high human activity and high mean residence times bear the majority of the pollution.

The extent of contamination in the coastal U.S. should be objectively assessed from a random, statistically unbiased dataset. This requires selection of sites without any preference to a specific type of location. Most of the data in COSED are, to various degrees, biased towards sites with elevated concentrations. The EMAP/EC sampling scheme, however, meets these requirements while assigning an areal extent to each measured concentration. The EMAP/EC dataset is, therefore, ideal for determining spatial extents for chemical concentrations over national and large regional scale. As the EMAP/EC Program expands to parts of the U. S. coast beyond the Virginian and Louisianian Provinces, it will become increasingly valuable.

While EMAP/EC data will provide a national assessment, directed sampling on local scales will be necessary to delineate the distributions of chemical concentrations that are sufficient to cause biological effects.

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APPENDIXES

APPENDIX I

Number of all parameter occurrences in COSED

PARAMETER	DETECTED	BELOW DETECTION	TOTAL
HIGH MW PAH	*3162*	*1580*	*4742*
LOW MW PAH	*2930*	*1906*	*4836*
TOTAL PAH	*3400*	*1472*	*4872*
TOTAL CHLORDANE	*1970*	*3824*	*5794*
TOTAL DIELDRIN	*1643*	*6936*	*8579*
TOTAL AROCHLORS	*8*	*863*	*871*
TOTAL DDT	*2440*	*4271*	*6711*
TOTAL PCB	*2441*	*1078*	*3519*
TOTAL PCB ANALOGS	*1276*	*193*	*1469*
GRAINSIZE	*2917*	*55*	*2972*
TOTAL ORGANIC CARBON (TOC)	2450	29	2479
ALUMINUM	4365	31	4396
ANTIMONY	2551	1507	4058
ARSENIC	6206	460	6666
CADMIUM	6920	1181	8101
CHROMIUM	8674	178	8852
COPPER	6251	96	6347
IRON	3505	61	3566
LEAD	11995	344	12339
MANGANESE	3898	61	3959
MERCURY	9671	729	10400
NICKEL	7150	357	7507
SELENIUM	2920	1547	4467
SILICON	1525	64	1589
SILVER	5442	683	6125
THALLIUM	2006	999	3005
TIN	2512	252	2764
ZINC	9082	82	9164
ACENAPTHENE	1246	1725	2971
ACENATHYLENE	1254	2518	3772
ANTHRACENE	1999	2499	4498
ANTHRACENE-PHENANTHRENE	44	21	65
BENZ[a]ANTHRACENE	2236	2149	4385
BENZO[a]PYRENE	2272	2148	4420
BENZO[b]FLUORANTHENE	1006	2027	3033

Entries in italics have been calculated and are not included in the Grand Total.

Number of parameters in COSED

PARAMETER	DETECTED	BELOW DETECTION	TOTAL
BENZOFLUORANTHENE MIXTURE	877	860	1737
BENZO[e]PYRENE	2000	605	2605
BENZO[GHI]PERYLENE	1333	2243	3576
BENZOPERYLENE MIXTURE	35	248	283
BIPHENYL	1203	1357	2560
BENZO[k]FLUORANTHENE	899	2061	2960
CARBAZOLE	0	238	238
CHRYSENE	2493	2204	4697
CHRYSENE-BENZ[a]ANTHRACENE	27	33	60
DIBENZ[a h] ANTHRARACENE	1554	2751	4305
DIMETHYLNAPTHALENE	1243	1315	2558
FLUORANTENE	2829	1904	4733
FLUORENE	1689	2461	4150
INDENO	1344	2506	3850
LINDANE	682	4113	4795
1-METHYLNAPHTHALENE	1379	1521	2900
2-METHYLNAPHTHALENE	1796	1630	3426
1-METHYLPHENANTHRENE	1471	1085	2556
NAPTHALENE	2134	1964	4098
PERYLENE	1954	676	2630
PHENANTH	2679	1953	4632
PYRENE	2886	1855	4741
TRIMETH	888	1207	2095
ALDRIN	548	7949	8497
CIS-CHLORDANE	1474	2793	4267
CHLORDANE MIX	239	1494	1733
TRAN-CHLORDANE	5	105	110
CIS-NONACHLOR	138	282	420
DIELDRIN	1374	6527	7901
ENDRIN	221	5269	5490
ENDRIN-ALDRIN	0	193	193
HEPTACHLOREPOXIDE	456	4744	5200
HEPTACHLOR	523	4859	5382
HEXACHLOROBENZENE	1229	3084	4313
KEPONE	0	21	21
MIREX	474	2769	3243
TOXAPHENE	35	865	900
TRANS-NONACHLOR	1184	1500	2684
O,P,DDD	893	1634	2527

Number of parameters in COSED

PARAMETER	DETECTED	BELOW DETECTION	TOTAL
O,P,DDE	508	2032	2540
O,P,DDT	440	1746	2186
P,P,DDD	1485	1122	2607
P,P,DDE	1738	855	2593
P,P,DDT	1067	1600	2667
DDE	9	204	213
DDT	7	204	211
DDTS	412	3394	3806
PCB8	609	1286	1895
PCB18	587	1586	2173
PCB28	865	1308	2173
PCB44	780	1392	2172
PCB52	900	1288	2188
PCB66	819	1352	2171
PCB101	1069	1117	2186
PCB105	691	1482	2173
PCB11077	295	757	1052
PCB118	975	1197	2172
PCB126	179	927	1106
PCB128	718	1469	2187
PCB138	1244	944	2188
PCB153	1073	1115	2188
PCB170	709	1412	2121
PCB180	978	1210	2188
PCB187	847	1326	2173
PCB195	639	1533	2172
PCB206	735	1452	2187
PCB209	790	1395	2185
PCBS	270	714	984
GRAVEL	541	527	1068
SAND	1313	9	1322
SILT	1392	38	1430
CLAY	1065	34	1099
GRAND TOTAL	**175117**	**140653**	**315770**

APPENDIX II

Sites in COSED with at least one "5xHigh" substance.

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
ODES	70 3800	42 3317	Ag	0	0
ODES	70 5719	42 4189	Cd	2	2
ODES	70 5758	42 4272	Zn,Pb	1	1
ODES	70 5878	42 4272	Zn,Pb	1	1
NS&T/BS	70 8267	42 5367	Cr,Cd	5	5
NS&T/BS	70 8500	42 5383	TPCB,Hg,Cr,Cd	5	5
NS&T/BS	70 8600	42 5250	Cr,Cd	5	5
ODES	70 8653	42 3444	Zn,Hg,Cd	12	18
NS&T/BS	70 8667	42 5217	Hg,Cr,Cd	5	5
NS&T/MW	70 8670	42 5188	Cr	5	5
NS&T/BS	70 8733	42 5167	TPCB,LPAH,Cr,Cd	5	5
NS&T/MW	70 8783	41 5870	TPCB	2	2
NS&T/BS	70 8917	41 5833	TPCB	2	2
ODES	70 8958	42 2667	Pb,Cd	36	46
EMAP/random	70 9117	41 6425	TCDANE,TPCB,Hg,Cu,Cd	2	2
ODES	70 9278	42 2653	Hg	57	65
ODES	70 9325	42 2722	Hg	61	67
ODES	70 9328	42.2764	Hg	62	66
ODES	70 9333	42 2681	Hg	58	66
ODES	70 9333	42 2833	Hg	63	66
ODES	70 9375	42 2625	Hg	61	71
ODES	70 9389	42 3175	Hg	74	76
ODES	70 9431	42 3431	Hg,Cd	80	81
ODES	70 9444	42 2556	Hg	63	73
ODES	70 9472	42 2828	Hg	72	85
ODES	70 9472	42 2944	Ag	74	88
ODES	70 9486	42 3222	Hg	89	93
ODES	70 9514	42 3306	Hg,Cd	98	98
ODES	70 9542	42 2514	Hg	63	74
ODES	70 9583	42 3417	Hg	98	99
ODES	70 9597	42 2861	Hg	77	101
ODES	70 9611	42 3069	Hg	93	102
NS&T/BS	70 9667	42 2867	Sn,Ag,Hg	78	99
NS&T/BS	70 9667	42 3483	Ag	98	101
ODES	70 9681	42 3361	Hg	102	103
NS&T/BS	70 9683	42 3317	TPCB,LPAH	101	103
ODES	70 9700	42 3228	Hg	98	102
NS&T/BS	70 9700	42 3300	TPCB,TDDT,HPAH,LPAH,Sn,Ag,Hg,Sb	99	102
ODES	70 9708	42 3472	Hg,Cd	101	104
ODES	70 9722	42 3278	Cd	100	105
NS&T/BS	70 9733	42 3067	TPCB,Sn,Ag,Hg	95	106
NS&T/MW	70 9733	42 3583	Ag	99	104
ODES	70 9736	42 3078	Hg	96	105
ODES	70 9806	42 3300	Hg,Cd	102	104
ODES	70 9806	42 3447	Ag,Cd	102	105
ODES	70 9806	42 3500	Hg,Cd	100	105
NS&T/BS	70 9817	42 3450	LPAH,Sn,Ag	104	107
ODES	70 9828	42 3097	Hg,Pb,Cd	100	107
ODES	70 9833	42 3200	Hg	100	106
ODES	70 9833	42 3347	Hg	105	106
ODES	70 9847	42 2750	Hg	76	94
ODES	70 9847	42 3172	Hg,Cd	100	106
ODES	70 9864	42 2922	Ag,Cd	91	104

LPAH Low MW PAH, HPAH High MW PAH, TPAH Total PAH,
TCDANE Total Chlordane TDIELD Total Dieldrin TDDT Total DDT, TPCB Total PCB
Random = No Site selected for monitoring or regulatory requirements
Random = Yes Site selected randomly
NE10 and NE20 Number of neighboring "5xHigh" sites within 10 and 20 km, respectively

"5xHigh"sites in COSED

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
NS&T/BS	70 9867	42 2917	Sn,Ag,Hg	91	105
ODES	70 9903	42 3222	Hg,Pb,Cd	103	106
ODES	70 9917	42 2764	Hg	84	94
ODES	70 9939	42 3264	Hg,Pb,Cd	106	107
ODES	70 9950	42 3181	Hg	103	106
ODES	70 9958	42 3217	Hg,Cd	102	106
ODES	70 9958	42 3569	Hg	98	104
ODES	70 9981	42 3244	Hg,Cd	106	107
ODES	71 0000	42 3125	Hg	101	107
ODES	71 0014	42 2806	Hg	88	95
ODES	71 0014	42 3278	Hg	105	105
NS&T/BS	71 0017	42 3283	Sn,Ag	107	107
ODES	71 0028	42 3228	Hg,Cd	106	106
NS&T/BS	71 0033	42 3417	Sn,Ag,Cd	101	106
ODES	71 0042	42 2883	Hg,Cd	92	103
ODES	71 0069	42 2847	Hg	90	98
ODES	71 0097	42 3431	Hg,Cd	100	106
ODES	71 0131	42 3042	Cd	98	105
ODES	71 0139	42 3217	Hg,Cd	106	106
ODES	71 0200	42 3106	Hg	105	107
ODES	71 0208	42 3606	Hg,Cd	98	105
ODES	71 0217	42 3181	Hg,Cd	106	106
ODES	71 0222	42 3083	Hg	104	107
ODES	71 0250	42 3522	Hg	98	106
ODES	71 0258	42 3061	Hg	103	106
ODES	71 0278	42 3033	Hg	102	107
ODES	71 0300	42 3514	Hg,Cd	98	106
ODES	71 0319	42 3078	Hg,Pb,Cd	103	105
ODES	71 0339	42 3853	Hg	80	94
ODES	71 0347	42 2911	Hg	88	98
ODES	71 0350	42 2911	Hg,Cd	88	98
ODES	71 0361	42 3597	Hg,Cu,Cd	94	99
ODES	71 0367	42 2911	Hg,Pb,Cd	88	98
ODES	71 0378	42 2922	Hg	88	98
NS&T/MW	71 0383	42 3042	TPCB,Ag	99	101
ODES	71 0389	42 3058	Hg	98	100
ODES	71 0389	42 3861	Hg	77	93
ODES	71 0394	42 3575	Hg,Pb,Cu,Cd	93	97
ODES	71 0417	42 2944	Hg	88	99
ODES	71 0422	42 3042	Hg	96	98
ODES	71 0431	42 2967	Hg	90	98
ODES	71 0431	42 3569	Hg,Pb,Cu,Cd	90	95
ODES	71 0431	42 3639	Hg,Cd	90	96
ODES	71 0436	42 3575	Hg,Pb,Cu,Cd	91	96
ODES	71 0439	42 3578	Hg,Pb,Cu,Cd	90	96
ODES	71 0458	42 3778	Hg,Cd	83	94
ODES	71 0458	42 3847	Hg,Pb,Cd	76	92
ODES	71 0472	42 3597	Hg,Pb,Cu,Cd	87	93
ODES	71 0472	42 3667	Hg,Pb,Cd	87	94
ODES	71 0472	42 3722	Hg,Pb,Cd	83	94
ODES	71 0472	42 3842	Hg	75	90
ODES	71 0475	42 3556	Hg,Cd	91	94
ODES	71 0486	42 3556	Hg,Pb,Cd	89	92
ODES	71 0486	42 3578	Hg,Cd	88	92
ODES	71 0486	42 3694	Zn,Hg,Pb,Cu,Cd	85	92
ODES	71 0500	42 3042	Hg,Cd	89	91
ODES	71 0500	42 3061	Hg,Pb,Cd	92	92
ODES	71 0500	42 3542	Hg	88	91
ODES	71 0514	42 3528	Hg,Pb,Cu,Cd	91	94
ODES	71 0528	42 3542	Hg,Pb,Cu,Cd	88	92
ODES	71 0556	42 3875	Zn,Hg,Pb,Cu,Cd	71	85
ODES	71 0597	42 3694	Zn,Hg,Pb,Cu,Cd	80	90
ODES	71 0597	42 3708	Hg,Pb	80	91

"5xHigh"sites in COSED

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
ODES	71.0639	42.3875	Zn,Hg,Pb,Cd	64	83
EMAP/non-random	71.0648	41.5234	LPAH	0	0
ODES	71.0681	42.3889	Hg,Pb,Cu,Cd	61	82
ODES	71.0694	42.3875	Zn,Hg,Pb,Cd	61	80
ODES	71.0722	42.3889	Hg,Pb,Cd	57	76
ODES	71.0722	42.3931	Zn,Hg,Pb,Cu,Cd	47	70
ODES	71.0750	42.3931	Hg,Pb,Cu,Cd	47	67
ODES	71.0958	42.3806	Hg,Pb,Cd	48	64
EMAP/random	71.1232	41.7667	Ag,Hg	1	2
EMAP/non-random	71.1637	41.7107	Ag,Hg	2	2
EMAP/random	71.2057	41.6982	Hg	1	2
NS&T/BS	71.3217	41.6583	TPCB	1	1
NS&T/BS	71.3533	41.6733	Ag	1	1
STORET	71.8497	41.3269	Hg	0	0
STORET	72.0756	41.4817	TCDANE	0	0
STORET	72.6433	41.7561	TCDANE	0	0
EMAP/non-random	72.8858	41.3133	HPAH,LPAH	1	1
STORET	72.9147	41.2622	Pb	1	1
EMAP/random	73.0720	41.2867	Sn,Cu	1	1
STORET	73.0797	41.3306	TPCB	1	1
NS&T/MW	73.1097	41.1678	TCDANE,HPAH	0	0
EMAP/non-random	73.2103	41.1597	TPCB,TDDT,HPAH,LPAH,Zn,Sn,Pb,Cu,Cr,Cd	2	2
STORET	73.2153	41.1561	Zn,Pb,Cr	2	2
STORET	73.2192	41.1506	Zn,Pb,Cr	2	2
NS&T/MW	73.4128	41.0567	LPAH	0	0
STORET	73.4667	40.5583	Cd	0	0
STORET	73.5381	41.0297	TCDANE	0	0
NS&T/MW	73.6690	40.8523	Ag	0	0
STORET	73.7450	40.4433	Ag,Hg,Cd	8	10
STORET	73.7500	40.3983	Cd	6	7
STORET	73.7500	40.4317	Ag,Hg,Cd	8	9
STORET	73.7500	40.4625	Ag	6	8
STORET	73.7867	40.4361	Ag	11	13
STORET	73.7889	40.3000	Ag,Hg,Sb	5	9
STORET	73.7917	40.3817	Hg	13	13
STORET	73.7917	40.3983	TDDT,LPAH,Ag,Hg,Pb,Cd,Sb	9	10
NS&T/MW	73.8012	40.8195	Ag	2	2
STORET	73.8200	40.3483	Hg	8	12
STORET	73.8200	40.3683	Hg	11	13
STORET	73.8200	40.3983	Ag,Hg,Cd	9	10
STORET	73.8300	40.4182	Ag,Hg,Cd	14	14
STORET	73.8500	40.3983	Ag,Hg,Cd	9	11
STORET	73.8533	40.3700	Ag,Hg	11	11
EMAP/random	73.8553	40.7768	HPAH,LPAH,Sn,Ag,Hg,Cu,Cd	4	4
EMAP/non-random	73.8615	40.7918	TPCB,HPAH,LPAH,Sn,Ag,Hg	3	4
STORET	73.8633	40.3608	Ag,Hg,Pb	10	11
STORET	73.8633	40.5592	Ag,Hg,Cd	0	0
EMAP/random	73.8928	41.0185	TPCB,Ag,Hg	0	0
STORET	73.9017	40.4167	Ag	6	7
EMAP/random	73.9317	40.7918	TPCB,HPAH,LPAH,Ag,Hg,Pb	2	3
EMAP/non-random	73.9385	40.7833	HPAH,LPAH,Ag,Hg	3	4
EMAP/random	73.9428	40.8833	Ag	0	3
EMAP/random	73.9452	41.7333	TPCB	0	0
EMAP/random	73.9667	41.2742	TPCB,TDDT,Hg,Cd	0	0
STORET	73.9833	40.2167	Ag,Hg	0	0
EMAP/random	73.9917	41.5160	HPAH,LPAH	0	0
NS&T/BS	74.0133	40.4533	TPCB,Sn,Ag,Hg,Cu,Cd	6	6
NS&T/BS	74.0183	40.5933	TPCB,Ag,Hg	3	5
NS&T/MW	74.0425	40.6897	HPAH,LPAH,Sn,Ag,Hg	4	5
NS&T/MW	74.0450	40.4878	TPCB,Ag,Hg	7	7
NS&T/BS	74.0483	40.5350	TPCB,Sn,Ag,Hg	8	8
NS&T/MW	74.0522	40.5662	TPCB,HPAH,Ag,Hg	6	7
EMAP/non-random	74.0747	40.6478	TPCB,Sn,Ag,Hg,Pb,Cd	5	5

"5xHigh"sites in COSED

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
EMAP/random	74 0750	40 4600	Sn,Ag,Hg	9	9
NS&T/BS	74 0833	40 4667	TPCB	9	10
NS&T/BS	74 0850	40 4833	Ag,Hg	10	10
EMAP/random	74 0867	40 7500	HPAH,LPAH	3	3
NS&T/BS	74 0900	40 4917	TPCB,Sn,Ag,Hg	10	10
EMAP/random	74 1108	40 0517	Cd	0	0
EMAP/non-random	74 1163	40 7047	Hg	6	9
STORET	74 1178	40 6917	Zn,Ag,Hg,Pb,Cr,Cd	7	11
NS&T/MW	74 1572	40 5065	TPCB,Sn,Ag,Hg	12	16
EMAP/non-random	74 1650	40 7500	TDIELD,TCDANE,TPCB,TDDT,HPAH,LPAH,Pb	2	2
NS&T/BS	74 1700	40 4917	TPCB,Ag,Hg,Cd	13	16
NS&T/BS	74 1717	40 4917	TPCB,Sn,Ag,Hg	13	16
STORET	74 1761	40 6461	TDDT,HPAH,LPAH,Zn,Ag,Hg,Pb,Cd,As	12	14
STORET	74 1836	39 6936	Hg	0	0
STORET	74 1964	40 6378	TDDT,HPAH,LPAH,Ag,Hg,Pb,Cd	12	14
STORET	74 2006	40 5994	TDDT,HPAH,Ag,Hg,Pb,Cd,As	13	17
EMAP/non-random	74 2033	40 6217	TDDT	12	15
STORET	74 2039	40 6167	TDDT,HPAH,LPAH,Zn,Ag,Hg,Pb,Cd	12	15
STORET	74 2055	40 5911	HPAH,Zn,Ag,Hg,Pb,Cd	11	16
STORET	74 2056	40 5911	Ag,Hg,Cd	11	16
STORET	74 2056	40 5911	Ag,Hg,Pb,Cr	11	16
STORET	74 2119	40 5706	Zn,Ag,Hg,Pb,Cd	17	17
STORET	74 2119	40 5706	Zn,Pb	17	17
STORET	74 2120	40 5706	Zn,Ag,Hg,Pb,Cd	17	17
STORET	74 2189	40 5581	Ag,Hg,Pb,Cd	18	19
STORET	74 2494	40 5244	Ag,Hg,Pb,As	15	17
STORET	74 2517	40 5508	HPAH,Zn,Ag,Hg,Pb,Cd	17	19
STORET	74 2589	40 5017	Ag,Hg,Pb,Cd	10	14
EMAP/non-random	74 2638	40 4903	Pb,Cd	10	10
EMAP/random	74 3000	40 5112	HPAH,LPAH,Pb,Sb	8	12
EMAP/random	74 7280	40 1667	Zn,Cd	0	0
EMAP/random	74 8363	40 1012	HPAH,LPAH,Cd	0	0
EMAP/random	75 0310	39 1485	Cd	0	0
EMAP/random	76 0082	36 9563	HPAH,LPAH	0	0
EMAP/random	76 2768	37 7153	Cd	0	0
NS&T/BS	76 2900	36 8100	HPAH,LPAH	1	1
EMAP/random	76 2938	36 8318	Cu	1	1
NS&T/BS	76 3333	39 1017	LPAH	3	3
STORET	76 3533	39 0533	Zn	2	2
NS&T/MW	76 4012	39 1600	LPAH	3	5
NS&T/BS	76 4167	38 9283	LPAH	0	1
STORET	76 4167	39 0617	Zn	2	3
EMAP/random	76 4428	38 8382	Sn	0	1
EMAP/random	76 4433	39 2700	Zn,Sn,Ag,Cu,Cd	3	4
EMAP/non-random	76 4433	39 2700	Sn,Ag,Cd	3	4
EMAP/random	76 4500	39 2750	TPCB,Zn,Sn,Ag,Hg,Cu,Cd	4	5
STORET	76 4517	39 1917	Zn,Pb	7	8
STORET	76 4683	39 1733	Zn	4	9
EMAP/non-random	76 4915	39 2433	Zn,Sn,Cr,Cd	10	11
NS&T/BS	76 5500	39 2267	TPCB,LPAH,Zn,Sn,Ag,Cu,Cd,Sb	7	8
EMAP/non-random	76 5517	39 2533	Sn,Se,Cu	5	7
EMAP/random	76 5570	39 2463	Sn,Se,Cu	5	6
NS&T/BS	76 5633	39 2450	TPCB,HPAH,LPAH,Sn,Cu,Cd,Sb	5	6
NS&T/BS	76 5783	39 2583	TPCB,LPAH,Sn	5	5
EMAP/random	76 9975	38 8697	Ag	0	0
EMAP/random	77 1918	37 3197	Pb	0	0
ODES	78 8489	42 8606	TDIELD	4	4
ODES	78 8542	42 8631	HPAH,LPAH,Hg	4	4
ODES	78 8672	42 8569	TDIELD,HPAH,LPAH,Zn,Hg,Pb,Cd	3	3
ODES	78 8672	42 8619	HPAH,LPAH,Pb	3	3
ODES	78 8844	42 8778	TCDANE,HPAH,LPAH	4	4
STORET	79 2833	33 3667	Zn,Pb	0	0
STORET	79 9306	32 8417	Hg	1	1

"5xHigh"sites in COSED

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
STORET	79 9700	32 7875	HPAH	1	1
STORET	80 0961	26 9485	Cd	0	0
REGION4	80 1800	25 7800	Hg	7	7
REGION4	80 1800	25 8500	TCDANE,HPAH,Pb	8	9
REGION4	80 1800	26 0900	TCDANE,Hg	1	1
STORET	80 1813	27 4583	Sn,Ag,Se,As,Sb	10	10
STORET	80 1833	27 4783	Sn,Ag,Se,As,Sb	10	10
REGION4	80 1900	25 7700	TDIELD,TCDANE,TPCB,LPAH,Hg,Pb	9	9
STORET	80 1914	27 1500	Hg	3	3
STORET	80 1922	27 1464	Ag	3	3
STORET	80 1947	27 1442	Hg	3	3
STORET	80 1953	27 4632	Sn,Ag,Se,Sb	9	9
STORET	80 1995	27 4760	Sn,Ag,Se,Sb	10	10
REGION4	80 2000	25 7700	Hg,Pb,Cu	9	9
STORET	80 2000	27 4417	Sn,Ag,Se,Sb	7	7
STORET	80 2000	27 4545	Sn,Ag,Se,As,Sb	7	7
STORET	80 2000	27 4753	Sn,Ag,Se,Sb	6	6
STORET	80 2000	27 4822	Sn,Se,Sb	7	7
STORET	80 2022	26 0875	Pb	1	1
STORET	80 2062	27 4632	Sn,Ag,Se,Sb	9	9
STORET	80 2092	27 4753	Sn,Ag,Se,As,Sb	9	9
REGION4	80 2100	25 7800	HPAH,Hg,Pb,Cu,Cr,Cd	8	8
STORET	80 2138	27 4575	Sn,Ag,Se,Sb	10	10
REGION4	80 2200	25 7800	TDIELD,TCDANE,HPAH,Hg,Pb,Cu,Cd	8	8
REGION4	80 2400	25 8000	TPCB,Hg,Pb	9	9
REGION4	80 2500	25 7900	HPAH,LPAH	8	8
REGION4	80 2500	25 8000	HPAH,Pb,Cd	8	8
STORET	80 2599	27 2069	TCDANE	3	3
REGION4	80 2600	25 7900	HPAH,Ag,Hg,Pb,Cu,Cd	7	8
REGION4	80 2600	25 8100	HPAH	9	9
NS&T/MW	80 3142	25 5232	TCDANE	0	0
STORET	80 3217	25 2228	Cd	3	3
STORET	80 3258	25 2233	Cd	2	2
STORET	80 3278	25 2233	Cd	1	1
STORET	80 3278	25 2239	Cd	2	2
STORET	80 3333	32 6333	TDDT	0	0
STORET	80 3483	27 5578	Ag,Se	0	0
STORET	80 4807	27 8576	Ag,Se	0	0
REGION4	80 6000	28 4100	Cd	0	0
STORET	80 6847	26 7487	TDDT	1	1
STORET	80 6943	26 7761	TDDT	1	1
STORET	80 7261	32 5442	As	3	3
STORET	80 7275	28 3617	Se	1	1
STORET	80 7278	32 5336	As	2	2
STORET	80 7278	32 5378	As	2	2
REGION4	80 7300	28 4100	TDIELD,Hg	1	1
STORET	80 7939	32 5286	As	3	3
STORET	80 8000	28 6153	Cd	1	1
STORET	80 8131	28 6867	Se	1	1
STORET	81 0117	29 2117	Se	0	0
STORET	81 0866	29 3418	Se	1	1
STORET	81 0922	29 3894	Se	1	1
NS&T/BS	81 2417	31 5383	HPAH	0	0
STORET	81 4700	31 1642	TDDT	1	1
STORET	81 5158	31 1875	Ag,Se,Hg,Cd	1	1
STORET	81 5528	30 3933	Cd	2	2
NS&T/BS	81 6083	30 3933	LPAH	2	4
NS&T/BS	81 6450	30 3950	HPAH,LPAH	3	4
NS&T/BS	81 6567	30 2400	LPAH	3	3
REGION4	81 6700	30 3200	HPAH	3	4
NS&T/BS	81 6817	30 1617	LPAH	1	1
REGION4	81 7000	30 3000	HPAH	2	4
REGION4	82 3900	27 8600	Cd	4	7

"5xHigh"sites in COSED

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
SFTB	82 4153	27 9417	TDIELD,TCDANE,TPCB,Pb,Cd	6	6
REGION4	82 4400	27 9400	Hg	5	6
SFTB	82 4406	27 9042	TCDANE,TPCB	7	7
SFTB	82 4425	27 9528	TDIELD,TCDANE,TPCB,TDDT,HPAH,LPAH,Zn, Pb,Cd	5	6
SFTB	82 4586	27 9403	TDIELD,TCDANE,TPCB,TDDT,HPAH,LPAH,Cd	5	6
REGION4	82 4600	27 8300	Pb,Cu,Cd	3	3
REGION4	82 4600	27 9200	Cd	6	6
REGION4	82 5100	27 5200	Hg	1	1
REGION4	82 5200	27 7800	Cd	1	1
REGION4	82 5700	27 5100	Hg	1	1
ODES	83 8422	43 6236	As	6	6
ODES	83 8567	43 6139	TDIELD	6	6
ODES	83 8611	43 6119	Cd	6	6
ODES	83 8633	43 6117	TCDANE,Cd,As	6	6
ODES	83 8694	43 6122	TDIELD,TCDANE,Cd	6	6
ODES	83 8861	43 6078	TDIELD	6	6
ODES	83 9094	43 5628	TDIELD	6	6
REGION4	83 9900	30 0800	Ag,Cd	0	0
REGION4	85 3200	29 8300	Hg	0	0
REGION4	85 5700	30 1400	Hg	2	2
REGION4	85 6300	30 1400	Cd	2	2
NS&T/MW	85 6320	30 1422	TPCB	3	3
NS&T/MW	85 6633	30 1500	HPAH,LPAH	3	3
NS&T/MW	86 4788	30 4808	TCDANE,TDDT	0	1
REGION4	86 5000	30 3900	HPAH	0	1
REGION4	87 2400	30 3900	HPAH	6	7
REGION4	87 2500	30 4000	Zn	7	7
STORET	87 2556	30 4028	Pb	7	7
REGION4	87 2600	30 4100	Zn,Pb,Cr	7	7
EMAP/random	87 2937	30 3702	Hg	8	9
REGION4	87 3000	30 3600	Cd	7	8
REGION4	87 3000	30 3700	Cd	7	8
STORET	87 3383	30 4333	Ag,Sb	8	9
STORET	87 3667	30 4250	TDDT	6	7
REGION4	87 3800	30 4600	HPAH,LPAH	2	6
ODES	87 4361	41 6678	TDIELD,HPAH,LPAH,Zn,Pb,Cd	6	6
ODES	87 4392	41 6736	TDIELD,TCDANE,HPAH,LPAH,Zn,Pb,Cu,Cd	6	6
STORET	87 4500	30 3833	Cd	2	3
ODES	87 4514	41 6608	TDIELD,TCDANE,HPAH,LPAH,Zn,Pb,Cu,Cd	6	6
EMAP/non-random	87 4583	30 3425	Hg	1	2
ODES	87 4597	41 6550	TDIELD,TCDANE,HPAH,LPAH,Zn,Ag,Hg,Pb, Cu,Cr,Cd	6	6
ODES	87 4714	41 6397	TDIELD,TCDANE,HPAH,LPAH,Zn,Ag,Hg,Pb, Cu,Cr,Cd	6	6
ODES	87 4722	41 6458	TDIELD,TCDANE,HPAH,LPAH,Zn,Ag,Hg,Pb, Cu,Cr,Cd,As	6	6
ODES	87 4806	41 6469	TDIELD,TCDANE,HPAH,LPAH,Zn,Ag,Hg,Pb, Cu,Cr,Cd	6	6
EMAP/non-random	89 2520	29 1497	Hg	0	0
EMAP/random	89 4930	29 3433	Hg	0	0
STORET	94 7867	29 6650	Ag	0	1
STORET	94 7958	29 3125	Ag	1	1
EMAP/random	94 8740	29 5733	LPAH	0	1
STORET	94 8903	29 2903	Cd	1	1
STORET	95 0528	29 5583	TCDANE,Zn	0	0
STORET	95 0925	33 3222	Ni	1	1
STORET	95 1306	33 3889	Ni	1	1
NS&T/BS	95 1633	29 7433	TCDANE,TPCB	0	0
STORET	95 1792	29 0950	Cd	1	1
STORET	95 2208	29 0183	Ag	1	1
STORET	95 2889	29 7500	TDIELD,TCDANE,TPCB,Ag,Hg,Cd	1	1
STORET	95 2894	29 6736	TCDANE	1	1

"5xHigh"sites in COSED

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
STORET	95 6875	29 0708	Ag,Cd	0	0
STORET	96 7200	28 3689	Hg	0	0
STORET	97 0311	27 8278	Ag	0	0
STORET	97 3458	27 8750	TCDANE	0	0
EMAP/random	97 4537	27 0013	Hg	0	0
STORET	97 4667	27 8208	Zn	1	1
STORET	97 5200	27 8439	Cd	1	1
STORET	97 6433	27 2900	Ag	0	0
STORET	117 1000	32 6667	HPAH	8	8
NS&T/BS	117 1333	32 6817	TPCB	8	8
NS&T/BS	117 1367	32 6833	Hg,Cu	7	7
NS&T/BS	117 1367	32 6850	TPCB	6	6
NS&T/BS	117 1383	32 6850	TPCB	5	5
NS&T/BS	117 1383	32 6867	TPCB,Hg,Cu	6	6
NS&T/BS	117 1383	32 6883	Hg	4	4
NS&T/BS	117 1400	32 6883	TPCB,LPAH,Cu	6	6
NS&T/BS	117 1417	32 6883	TPCB,HPAH	6	6
STORET	117 6917	33 4614	Sn	3	3
STORET	117 6953	33 4600	Hg	3	3
STORET	117 7003	33 4606	Sn	3	3
STORET	117 7044	33 4619	Cd	3	3
STORET	117 7488	33 6524	TDDT	0	0
STORET	117 8861	33 6325	Sn	7	8
STORET	117 8881	33 6378	Sn	7	8
STORET	117 8919	33 6231	TDDT,Sn	7	8
STORET	117 8922	33 6183	Sn,Se	7	8
STORET	117 9031	33 6058	Sn	8	8
STORET	117 9247	33 6186	Sn,Hg	8	8
STORET	117 9261	33 6114	Sn,Hg	8	8
ODES	117 9536	33 5786	TCDANE,Sb	8	8
ODES	117 9844	33 5661	TDIELD	4	8
STORET	118 0594	33 7125	TCDANE,Sn,Cu	1	1
STORET	118 0736	33 7267	TCDANE,Sn	2	2
NS&T/BS	118 1670	33 7333	TDDT	13	14
NS&T/MW	118 1740	33 7237	TDDT	13	13
NS&T/BS	118 1767	33 7433	TDDT	13	13
NS&T/BS	118 1783	33 7417	TDDT	14	14
NS&T/BS	118 2500	33 7117	TDDT	13	14
NS&T/BS	118 2567	33 7017	TDDT	14	14
NS&T/BS	118 2567	33 7083	TDDT	13	13
NS&T/BS	118 2567	33 7133	TDDT	13	14
NS&T/BS	118 2570	33 7100	TDDT	16	16
NS&T/BS	118 2583	33 7083	TPCB,TDDT	14	14
NS&T/BS	118 2583	33 7117	TDDT	12	13
NS&T/BS	118 2617	33 7000	TDDT	16	16
NS&T/BS	118 2633	33 7117	TDDT	14	14
NS&T/BS	118 2667	33 6983	TDDT	15	16
NS&T/MW	118 2770	33 7103	TDDT	13	13
ODES	118 2811	33 6231	Cd	8	12
NS&T/MW	118 3500	33 7108	TDIELD,TPCB,TDDT,Ag,Cd	11	12
NS&T/MW	118 4140	33 8235	TDDT	0	0
NS&T/BS	118 5483	33 9517	Ag	3	3
NS&T/BS	118 5550	33 9417	Ag	3	3
NS&T/BS	118 5670	33 9333	Cr	3	3
NS&T/BS	118 5683	33 9383	TDDT,Ag	3	3
STORET	118 6814	34 0347	Cd	0	0
STORET	119 7472	36 6986	Zn,Cd	0	0
ODES	120 8772	35 3864	TDIELD,TDDT,Ag,Se,Cd,Sb	1	1
ODES	120 8772	35 3900	TDDT	1	1
ODES	120 8781	35 3875	TDDT	2	2
STORET	121 6400	37 9764	Sb	0	0
STORET	121 8592	38 0300	Cr	0	0
STORET	122 2174	47 9882	HPAH,LPAH	2	2

"5xHigh"sites in COSED

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
STORET	122 2186	47 9833	LPAH,Cd	3	3
STORET	122 2188	47 9846	LPAH,Zn	3	3
STORET	122 2209	47 9882	Cd	2	2
SFTB	122 2472	37 7864	TDIELD,Hg	10	10
SFTB	122 2620	37 7939	Hg	11	11
SFTB	122 2933	37 8019	TPCB,Hg	11	13
SFTB	122 2933	37 8042	Hg	11	13
SFTB	122 2944	37 8018	TPCB,Hg	11	13
SFTB	122 2944	37 8043	TPCB	11	13
SFTB	122 2945	37 8043	HPAH,Hg	11	13
STORET	122 3025	47 5192	Sn	37	37
STORET	122 3094	47 5267	Sn	37	37
NS&T/BS	122 3100	38 0483	Hg,Cr	0	0
STORET	122 3178	47 5364	HPAH,LPAH,Pb,Cd	38	39
STORET	122 3186	47 5353	HPAH,Sn	39	40
STORET	122 3294	47 5431	HPAH,LPAH,As	40	44
STORET	122 3353	47 5461	Sn	40	44
SFTB	122 3360	37 7914	Sb	12	14
SFTB	122 3360	37 7931	Sb	12	14
SFTB	122 3360	37 7946	Sb	12	14
STORET	122 3364	47 5456	Sn	40	44
NS&T/BS	122 3367	37 7833	Hg	15	16
STORET	122 3394	47 5567	HPAH,LPAH,Zn,Cd	40	44
STORET	122 3397	47 5906	Sn	43	44
STORET	122 3408	47 5569	HPAH,Sn	41	43
STORET	122 3422	47 5569	Sn	41	43
STORET	122 3433	47 5736	HPAH,Sn	42	44
STORET	122 3433	47 5853	HPAH,Sn	42	43
STORET	122 3464	47 5683	Sn,Pb	43	44
STORET	122 3469	47 5678	Sn	43	44
STORET	122 3483	47 5675	HPAH	43	44
NS&T/BS	122 3500	47 5917	TPCB	42	43
STORET	122 3511	47 5883	HPAH,LPAH	43	44
NS&T/BS	122 3517	47 5950	TPCB	42	43
STORET	122 3528	47 5881	HPAH,LPAH,Pb	43	44
ODES	122 3531	47 5958	Zn,Ag	43	44
NS&T/BS	122 3533	47 5900	TPCB,HPAH	42	43
STORET	122 3547	47 5878	HPAH,LPAH,Zn,Sn,As	42	43
STORET	122 3561	47 5886	HPAH,LPAH,Sn,Pb	44	45
NS&T/BS	122 3567	47 5917	TPCB	43	44
STORET	122 3575	47 5811	HPAH,LPAH,Pb	42	44
STORET	122 3578	47 5756	HPAH,LPAH,Sn	42	45
STORET	122 3578	47 5878	HPAH,LPAH	42	43
STORET	122 3586	47 5811	HPAH	42	44
STORET	122 3589	47 5753	HPAH,Sn,Pb	42	45
STORET	122 3589	47 5872	HPAH	43	44
ODES	122 3597	47 2613	Cd,As	64	65
STORET	122 3597	47 5747	HPAH	43	46
STORET	122 3600	47 5811	HPAH	41	43
STORET	122 3600	47 5864	HPAH,LPAH,Zn,Sn,Pb,As,Sb	43	44
ODES	122 3601	47 2627	Cd	63	64
SFTB	122 3606	37 8218	Hg	14	16
ODES	122 3628	47 2636	HPAH,Cd	65	66
NS&T/BS	122 3633	47 5900	TPCB	43	44
ODES	122 3641	47 2643	HPAH	65	66
SFTB	122 3643	37 9125	Hg	3	7
STORET	122 3658	47 5858	HPAH,LPAH	44	45
ODES	122 3665	47 2663	HPAH,LPAH,Cu,Cd,As	67	67
ODES	122 3667	47 2658	HPAH,Cd,As	66	66
STORET	122 3667	47 5950	TPCB	44	44
NS&T/BS	122 3670	37 7000	HPAH	4	7
ODES	122 3673	47 2655	HPAH,LPAH,Cu,Cd,As,Sb	66	67
SFTB	122 3688	37 9215	TDIELD,TDDT,Hg	3	7

"5xHigh"sites in COSED

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
STORET	122 3692	47 5836	HPAH,LPAH	44	45
ODES	122 3696	47 2672	HPAH,Cd,As	67	67
ODES	122 3707	47 2683	HPAH,Cd	67	67
ODES	122 3722	47 2691	HPAH,Cd,As	67	67
ODES	122 3724	47 2702	Cd,As	67	67
ODES	122 3726	47 2696	HPAH,LPAH,Cd,As	67	67
ODES	122 3732	47 2692	HPAH,LPAH,Cu,Cd,As	67	67
ODES	122 3737	47 2703	LPAH	67	67
SFTB	122 3749	37 9253	TDIELD,TDDT,Hg	3	6
ODES	122 3750	47 2707	HPAH	67	67
ODES	122 3774	47 2561	Cd	66	67
ODES	122 3841	47 2619	HPAH,LPAH,Cd	65	66
ODES	122 3847	47 2616	Cd	66	67
ODES	122 3851	47 2613	Cd	66	67
SFTB	122 3867	37 7472	HPAH,LPAH,Ag,Hg,As,Sb	7	12
ODES	122 3868	47 2629	Cd	67	67
ODES	122 3886	47 2647	Cd	67	67
SFTB	122 3888	37 7472	HPAH,LPAH,Ag,Sb	7	12
ODES	122 3890	47 2767	LPAH	67	67
ODES	122 3891	47 2643	Cd	67	67
ODES	122 3895	47 2640	Cd	67	67
ODES	122 3903	47 2651	Cd	67	67
ODES	122 3905	47 2658	Cd	66	66
ODES	122 3909	47 2654	Cd	67	67
ODES	122 3915	47 2650	Cd	67	67
ODES	122 3929	47 2666	Cd	67	67
ODES	122 3948	47 2684	LPAH,Cd	67	67
ODES	122 3952	47 2676	Cd	67	67
ODES	122 3953	47 2778	LPAH	67	67
ODES	122 3958	47 8300	Sb	1	1
ODES	122 3961	47 2671	Cd	68	68
ODES	122 3968	47 2786	LPAH	68	68
ODES	122 3983	47 2788	Hg,Cu	68	68
SFTB	122 3994	37 7479	Ag,As,Sb	8	8
NS&T/BS	122 4000	37 8833	TDDT	4	8
ODES	122 4009	47 2727	LPAH,Cd	70	70
ODES	122 4025	47 2812	LPAH	70	70
NS&T/MW	122 4060	47 6278	TCDANE	42	48
ODES	122 4120	47 2875	Cd	73	73
ODES	122 4121	47 2663	LPAH,Pb,Cu,Cd,As	73	73
ODES	122 4139	47 4819	Ag	8	20
ODES	122 4146	47 2680	Pb,Cd	73	73
ODES	122 4152	47 2627	LPAH	72	72
ODES	122 4153	47 3494	Ag	51	69
SFTB	122 4156	38 0119	Sb	2	5
ODES	122 4161	47 2693	Pb	73	73
ODES	122 4161	47 2884	Cd	73	73
ODES	122 4167	47 2643	LPAH	74	74
NS&T/MW	122 4180	47 5758	TCDANE	46	48
SFTB	122 4181	38 0114	Sb	2	5
ODES	122 4183	47 2701	LPAH	74	74
ODES	122 4193	47 2669	LPAH	74	74
SFTB	122 4197	38 0100	As,Sb	2	5
ODES	122 4197	47 6369	Sb	39	45
ODES	122 4211	47 5297	Ag	36	44
ODES	122 4261	47 7486	As,Sb	2	2
ODES	122 4264	47 2560	HPAH,LPAH,Cd	74	75
STORET	122 4277	47 6243	HPAH,LPAH,Zn,Pb	41	46
ODES	122 4285	47 2681	LPAH,Cu,Cd	75	75
ODES	122 4291	47 2518	LPAH,Pb,Cd	74	75
STORET	122 4292	47 6281	Pb	39	46
ODES	122 4302	47 2622	LPAH,Pb,Cu,Cd	75	75
ODES	122 4302	47 2662	LPAH	75	75

"5xHigh"sites in COSED

ORIGIN	LONGITUDE	LATITUDE	5xHIGH	NE 10	NE 20
ODES	122 4305	47 2426	HPAH,LPAH,Pb,Cd	73	74
ODES	122 4308	47 2475	LPAH,Pb,Cd	74	74
ODES	122 4309	47 2462	LPAH,Hg,Pb,Cd	74	74
ODES	122 4310	47 2448	HPAH,LPAH,Pb,Cd	74	74
ODES	122 4313	47 2638	LPAH,Hg,Cu,Cd,As	75	75
ODES	122 4315	47 2508	HPAH,LPAH,Pb,Cd	74	75
ODES	122 4317	47 2520	LPAH,Pb,Cd	74	75
ODES	122 4323	47 2531	LPAH,Pb,Cd	74	75
ODES	122 4324	47 2553	Cd	74	75
ODES	122 4328	47 2562	LPAH,Cd	74	75
ODES	122 4339	47 2583	HPAH,LPAH,Cd	74	75
ODES	122 4355	47 2604	LPAH	74	75
ODES	122 4356	47 6697	Zn	12	37
ODES	122 4358	47 2619	HPAH,LPAH	74	74
ODES	122 4398	47 2636	LPAH	75	75
ODES	122 4561	47 6417	Ag	23	26
ODES	122 4619	47 2837	LPAH,Cd	73	73
ODES	122 4651	47 2770	LPAH	71	71
STORET	122 4942	47 6114	HPAH	11	12
STORET	122 4944	47 6131	HPAH	11	12
ODES	122 4955	47 2950	LPAH,Cu,Cd,As	44	44
STORET	122 4956	47 6194	Cd	11	12
STORET	122 4967	47 6164	HPAH	11	12
STORET	122 4978	47 6181	HPAH	11	12
ODES	122 4995	47 2983	Zn,Se,Hg,Pb,Cu,Cd,As,Sb	41	41
ODES	122 5008	47 3022	Cd,As	41	41
ODES	122 5034	47 3011	HPAH,LPAH,Zn,Se,Hg,Pb,Cu,Cd,As,Sb	38	38
ODES	122 5034	47 3014	Zn,Hg,Pb,Cu,Cd,As,Sb	38	38
ODES	122 5042	47 3017	HPAH,LPAH,Zn,Se,Ni,Hg,Pb,Cu,Cd,As,Sb	39	39
ODES	122 5158	47 3089	Zn,Pb,Cu,Cd,As,Sb	34	34
ODES	122 5207	47 3106	As	28	29
ODES	122 5836	47 3356	HPAH,LPAH	8	8
STORET	122 6300	47 5596	Pb	2	2
STORET	122 6592	47 5514	Pb	2	2
STORET	122 6658	47 5486	Zn,Cd	2	2
NS&T/BS	123 0300	38 3050	Cr	0	0
NS&T/BS	123 0580	37 6567	Cd	0	0
ODES	123 4572	48 1353	Cd	0	0
NS&T/BS	124 1233	40 8350	Cr	1	1
NS&T/MW	124 1680	40 8220	TCDANE	1	1
STORET	124 2014	43 3633	Cu	2	2
STORET	124 2100	43 3733	Cu,Cr	2	2
NS&T/BS	124 2170	43 4000	Ag,Cd	2	2
NS&T/MW	124 2320	41 7212	Ni,Cr	0	0
STORET	124 3106	43 2964	Cr	0	0

APPENDIX III

Spatial Distribution of Sediment Contaminants from EMAP Data.

EMAP data from randomly selected sites were used to calculate cumulative areal coverage of copper concentrations for the total estuarine area in Virginian and Louisianian Provinces (Figure **8**). That calculation has been extended here, and cumulative areal coverages have been calculated for each metal and each aggregate organic group. EMAP statistical design calls for four years of sampling to achieve complete coverage of the provinces and estuarine classes (small, large, and tidal rivers). With only two years of sampling data, there is some uncertainty associated with the results, however, it is expected that these results are representative of the remaining two years. These distribution plots would represent the average extent of contamination along the Northeast and Gulf of Mexico coast of the United States, as discussed in page 26. It is observed that in all cases in Figures **15-18**, that concentrations in excess of "5xHigh" are found over only a very small percentage of the total area and that over 90% of the total area has contaminant concentrations below the "High".

Concentrations below the detection limit are reflected in these graphs. Many of the curves do not begin at the 0% cumulative area, owing to a number of sites below the detection limit. This is particularly noticeable for the organics for example, only 32% of the area analyzed by EMAP had concentrations above the DL for total dieldrin. As analytical methods improve the percentage of area below DL will decrease as well. The concentrations in these areas, however, will be lower than the current lowest concentrations, and should not affect the upper end of the distribution relative to "High" and "5xHigh".

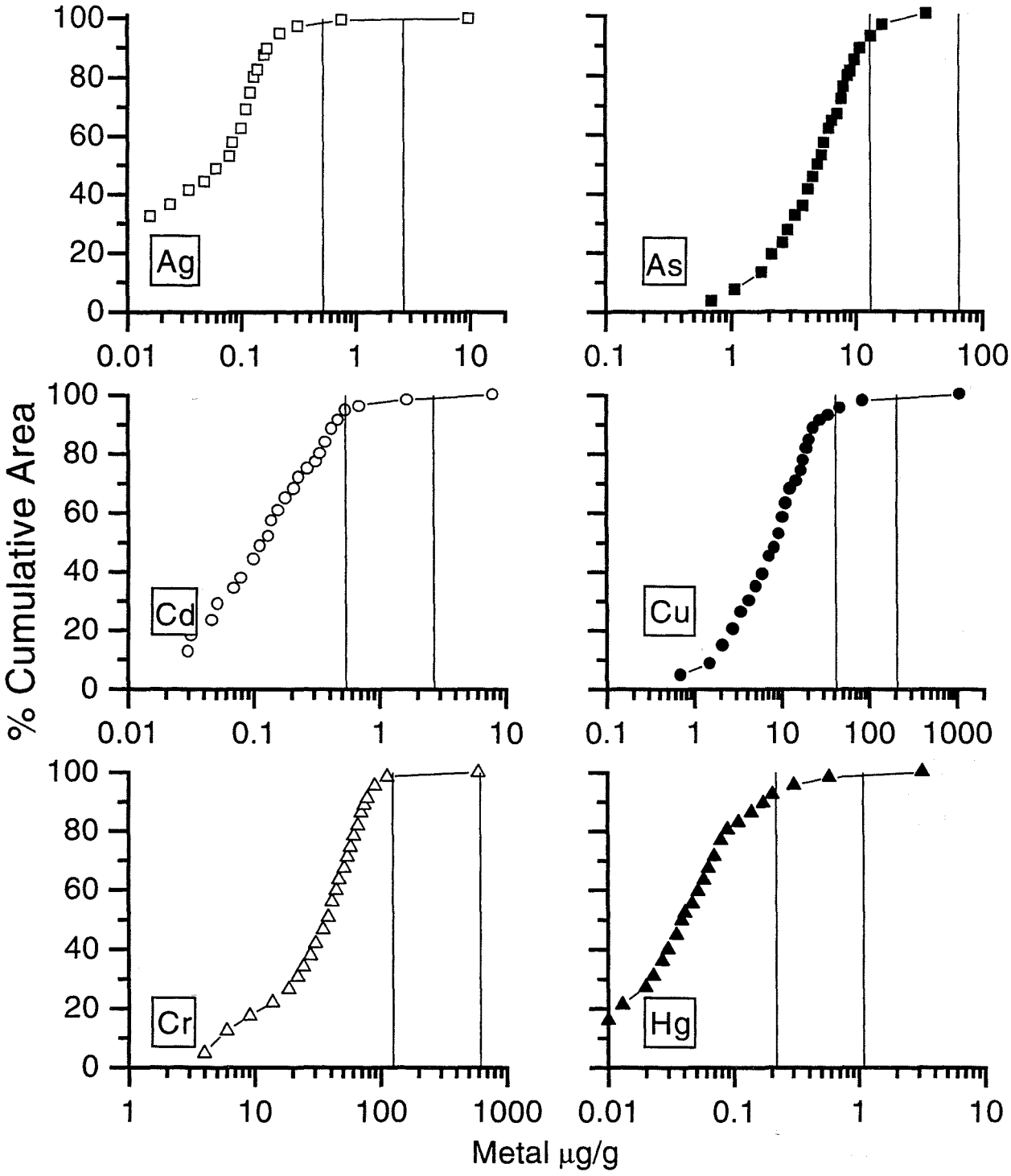

Figure **15**. Cumulative areal plots calculated from EMAP data for the Virginian and Louisianian Provinces for Ag, As, Cd, Cu, Cr, and Hg The vertical lines correspond to the NS&T/MW "High" (lower concentration) and "5xHigh" (greater concentration)

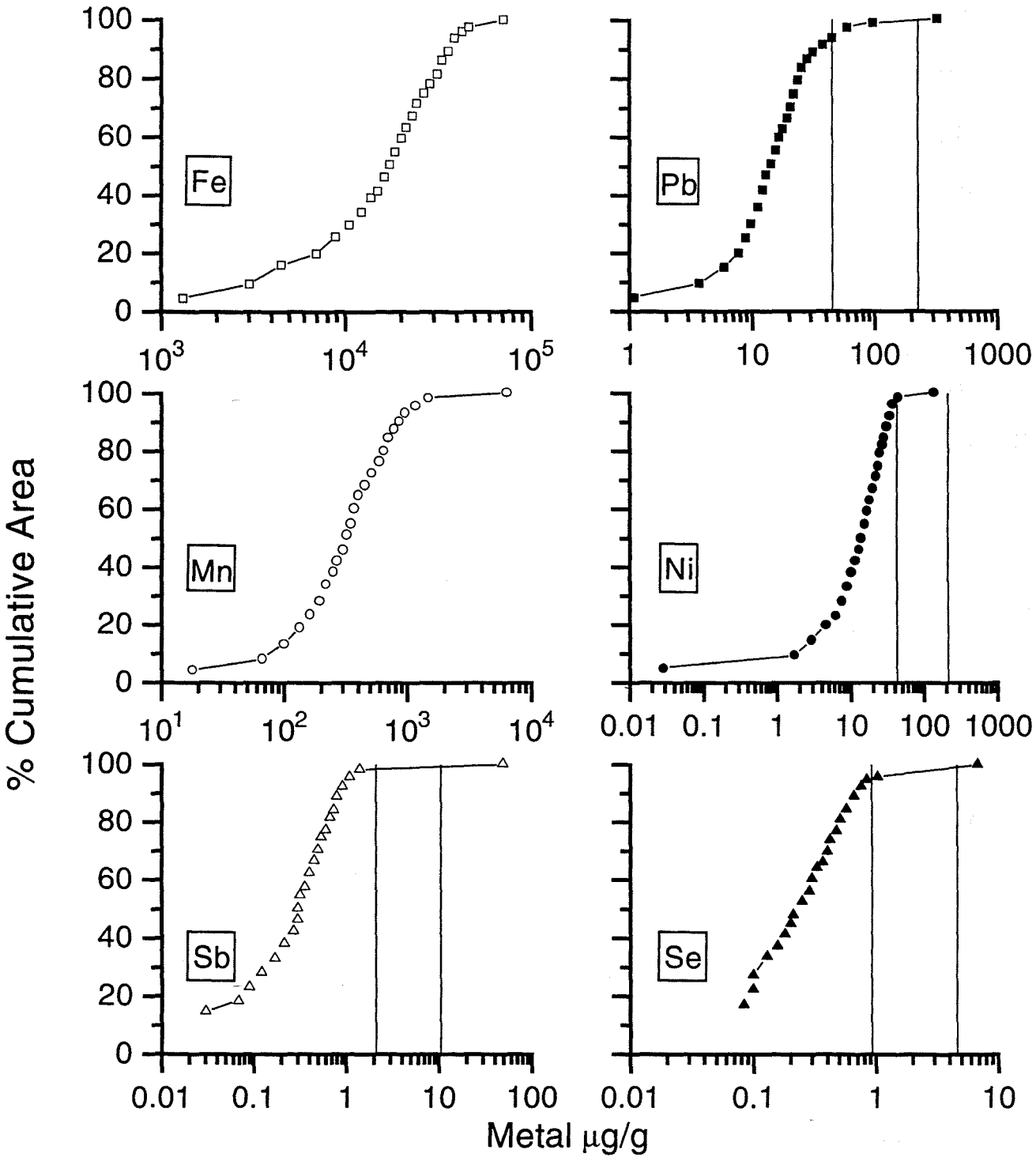

Figure **16** Cumulative areal plots calculated from EMAP data for the Virginian and Louisianian Provinces for Fe, Pb, Mn, Ni, Sb, and Se. The vertical lines correspond to the NS&T/MW "High" (lower concentration) and "5xHigh" (greater concentration).

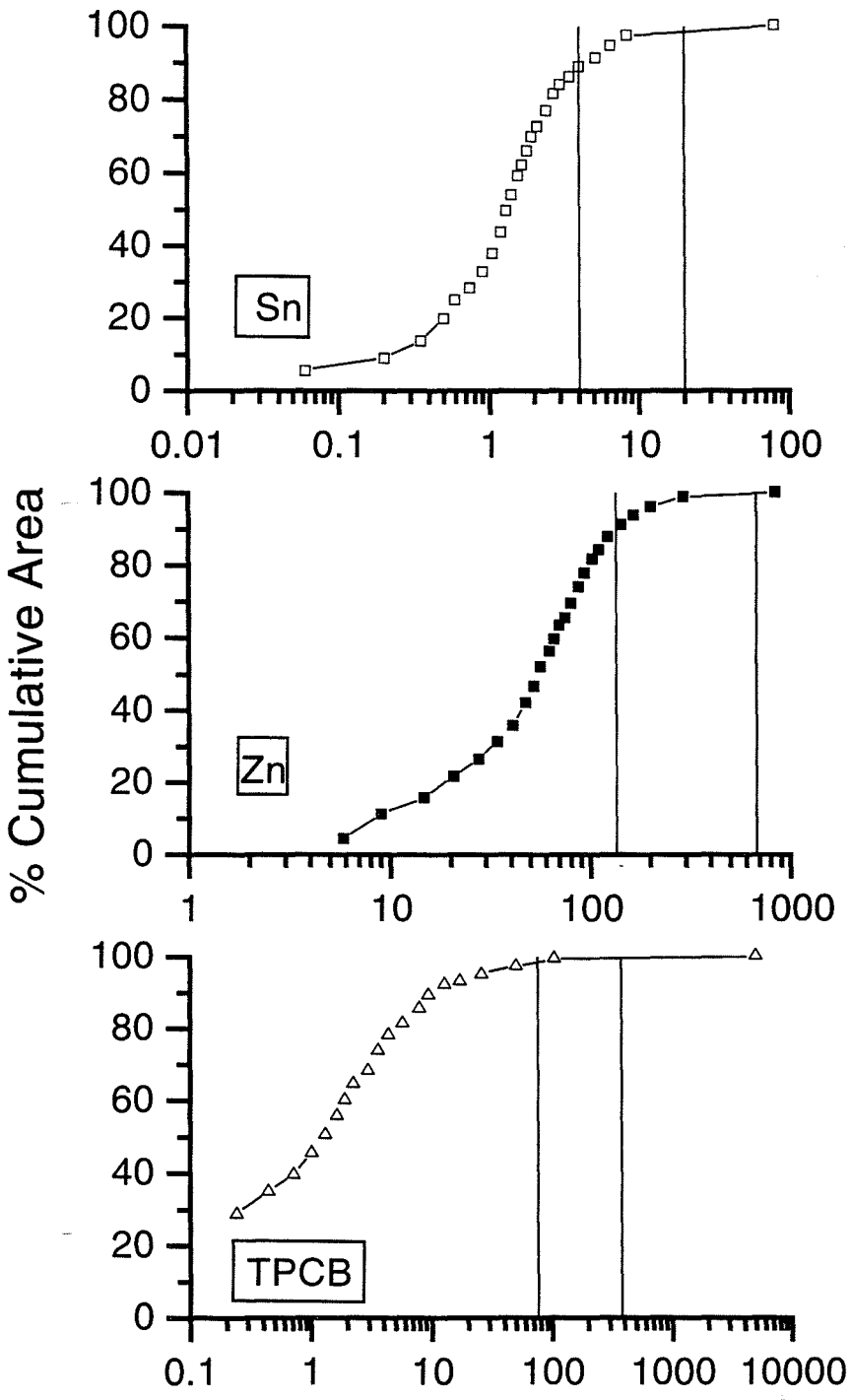

Figure **17**: Cumulative areal plots calculated from EMAP data for the Virginian and Louisianian Provinces for Sn, Zn and total PCB. The vertical lines correspond to the NS&T/MW "High" (lower concentration) and "5xHigh" (greater concentration) Concentrations are µg/g for Sn and Zn, and ng/g for Total PCB

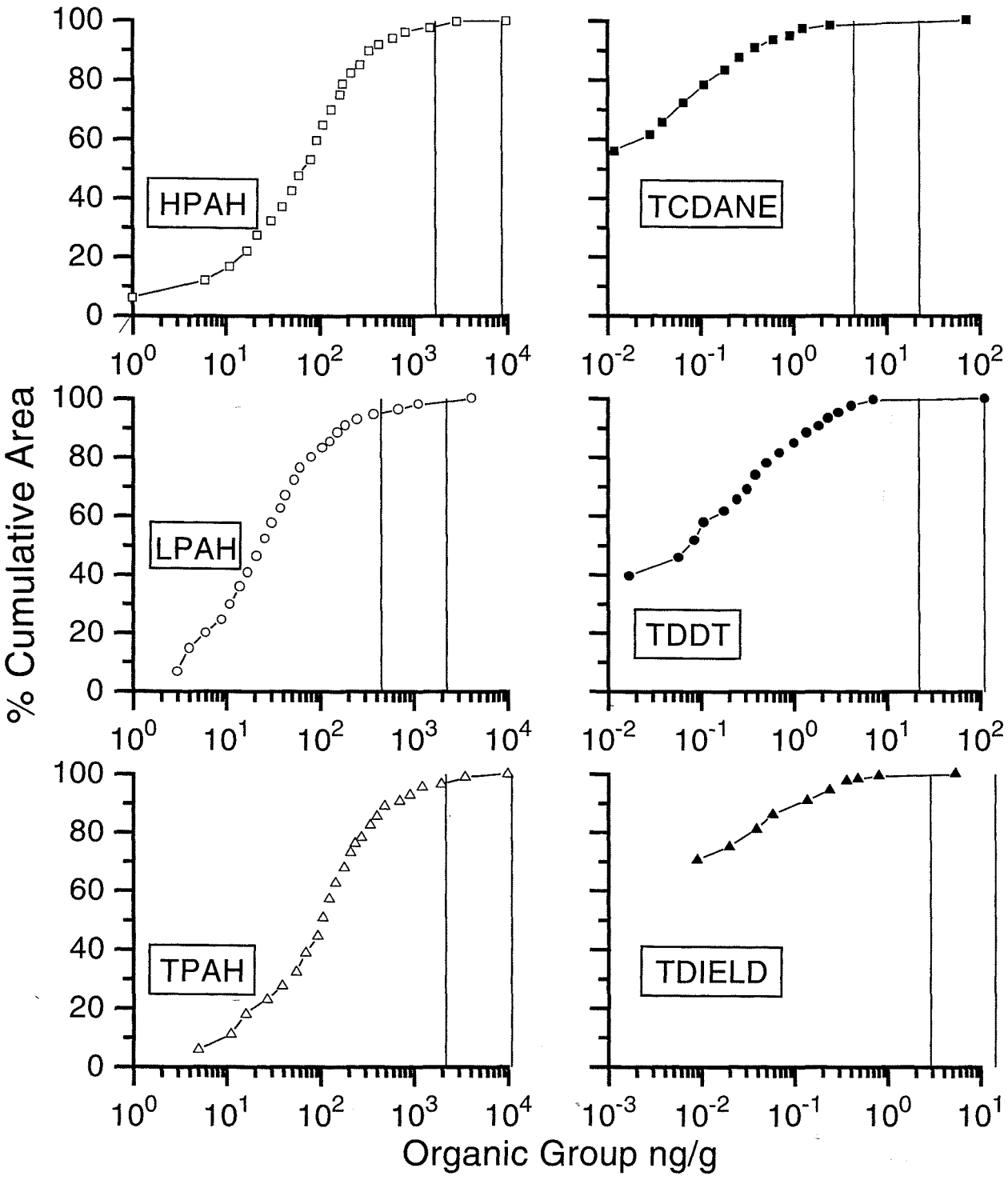

Figure **18** Cumulative areal plots calculated from EMAP data for the Virginian and Louisianian Provinces for organics The vertical lines correspond to the NS&T/MW "High" (lower concentration) and "5xHigh" (greater concentration)